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ALBANY
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1918

The University of the State of New York

NEW YORK STATE MUSEUM

70th ANNUAL REPORT

1916

In 2 volumes

VOLUME I

REPORT OF THE DIRECTOR 1916

AND

APPENDIX I

TRANSMITTED TO THE LEGISLATURE APRIL 23, 1917

ALBANY

THE UNIVERSITY OF THE STATE OF NEW YORK

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STATE OF NEW YORK

No. 44

IN ASSEMBLY

April 23, 1917

70th ANNUAL REPORT

OF THE

NEW YORK STATE MUSEUM

VOLUME I

To the Legislature of the State of New York

We have the honor to submit herewith, pursuant to law, as the 70th Annual Report of the New York State Museum, the report of the Director, including the reports of the State Geologist and State Paleontologist, and the reports of the State Entomologist and the State Botanist, with appendixes.

PLINY T. SEXTON,

Chancellor of the University

JOHN H. FINLEY,

*President of the University and
Commissioner of Education*

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The University of the State of New York

Department of Science, April 11, 1917

Dr John H. Finley

President of the University

SIR: I beg to transmit to you herewith for publication as a bulletin of the State Museum, the report of the Director of the Museum for the last fiscal years.

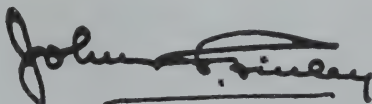
Very respectfully yours

JOHN M. CLARKE

Director

THE UNIVERSITY OF THE STATE OF NEW YORK
OFFICE OF THE PRESIDENT

Approved for publication this 18th day of April, 1917

A handwritten signature in dark ink, appearing to read "John H. Finley". The signature is written in a cursive style with a horizontal line underneath the name.

President of the University

New York State Museum Bulletin

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ALBANY, N. Y.

APRIL 1, 1917

The University of the State of New York

New York State Museum

JOHN M. CLARKE, Director

THIRTEENTH REPORT OF THE DIRECTOR OF THE STATE MUSEUM AND SCIENCE DEPARTMENT

INCLUDING THE SEVENTIETH REPORT OF THE STATE MUSEUM, THE THIRTY-SIXTH
REPORT OF THE STATE GEOLOGIST AND THE REPORT OF THE STATE
PALEONTOLOGIST FOR 1916

Regents committee on the State Museum:

Charles B. Alexander M.A. LL.D. Litt.D., Tuxedo

Herbert L. Bridgman M.A., Brooklyn

Walter Guest Kellogg B. A., Ogdensburg

INTRODUCTION

This report covers all divisions of the scientific operations and museum work under the supervision of The University of the State of New York and has reference to the progress made therein during the fiscal year 1915-16. It constitutes the 70th consecutive annual report of the State Museum, the 36th annual report of the State Geologist (consecutive since 1881) and the report of the State Paleontologist for 1916. It is introductory to all memoirs and bulletins issued by this Department during the year named.

The subjects presented in this report are considered under the following captions:

I Legal Status and Scope of the State Museum

II Present Condition of the Museum

III Condition of the Scientific Reservations Belonging to the
Museum

IV Department Publications

V Considerations for Future Growth of the Museum

VI Report of the Geological Survey

- VII Report of the State Botanist
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I

LEGAL STATUS AND SCOPE OF THE STATE MUSEUM

The broad scope of the State Museum was clearly and succinctly defined in the Education Law (as amended in 1910) under article 3, which relates to the objects and functions of the University. Section 54 of that law reads as follows: "All scientific specimens and collections, *works of art, objects of historic interest* and similar property appropriate to a general museum, if owned by the State and not placed in other custody by a specific law, *shall constitute the State Museum.* . . . The State Museum shall include the work of the State Geologist and Paleontologist, the State Botanist and the State Entomologist, who, with their assistants, shall be included in the scientific staff of the State Museum."

This definition of scope is broad and clear. It is the specific expression of the intent of the people of the State to constitute and maintain not alone a state museum of science, but a state museum of art, a state museum of history and a state museum which may depict any other field of civic and educational concern which in the judgment of the Regents of the University, would be justified by public interest. The spirit of the law where its sentences bear upon the creation of a museum of art and a museum of history is so obvious as to be constructively a command. The wish of the people and the desire of the Board in regard to this expansion of the actual museum nearer to the ideal of the museum expressed in the law have become a matter of record. It is then to be understood that the existing science museum of the State represents the development of only one phase of what should be, and what within the implied intention of the law is to be, the State Museum.

II

PRESENT CONDITION OF THE MUSEUM

During the year the erection of additional exhibit cases with their displays has reached close to the walls of the Museum halls, and has practically preempted all the available floor space of the Museum. Further exhibitions must be carefully planned with reference to the amount of floor space to be occupied, lest too serious encroachment be made on the aisle space necessary for a dignified presentation of the displays. These physical limitations of the Museum necessitate the constant renovation of the exhibits, the substitution of specimens by materials of a better quality; and while these physical boundaries of the Museum are to be regretted because of the constraints which they compel, yet they afford an opportunity of beautification which might not otherwise be practicable. There is an undoubted and obvious advantage in the restriction of a museum to a reasonable area. A museum in which the floor space is without restraining limitations and is distributed over several floors, often becomes a receptacle of materials which are put on display solely for the purpose of filling space, and are quite likely to detract from the impressiveness and quality of the museum as well as to add to the fatigue and labor of the visitor. The thought is kept in mind that a public museum of this kind will be the resort of the people rather more than of the special student, and while the demands of a scientific and orderly classification, the requirements of scientific students, are not lost sight of, the arrangement generally and the mode of display must be of a sort to elicit the interest of the average visitor.

The largest addition of moment to the collections has been that returned to the Museum from the Panama-Pacific Exposition. The exhibit made in San Francisco was entirely given over to an illustration of the mineral industry of New York, and the materials sent there were in a large measure brought together for that specific end. With their return they constitute a very important addition to the Museum displays in practical and applied geology. With them came fifteen cases which had been built to accord with the case patterns adopted in the Museum, and though these were of somewhat inferior quality of material, they have been adapted to the geology exhibits, and the geology hall is now fairly well

crowded. This condition made necessary the diminution of some of the aisle space, and it is not likely that the geology collections can now be much expanded without the most economic form of distribution of the material. It should be recorded that these new accessions were the property of the New York Commission of the Panama-Pacific Exposition, and should be regarded as a donation from them. To provide room for these accessions, and the necessary rearrangement of the cases, the work was in progress for a considerable portion of the year. While the exhibit as it now stands is fairly representative of the economic resources of this State in the present stage of knowledge and utilization, there is still a very large opportunity for further expansion in order to illustrate the varied industrial applications of the products of mine and quarry and to portray by models the technic and methods employed in their extraction and elaboration. The use of models has an undoubted educational value, as is evinced by the degree of attention which they attract from visitors.

In the paleontology hall some important additions have also been made. Two new cases were added in the hall of fossil plants, one in the hall of vertebrates, and four in the hall of invertebrates. Some of the cases have been rearranged and the result of this work has been the creation of two very attractive exhibits, one of the starfishes and crinoids, and one of the Pleistocene fossils deposited by the marine waters of the Lake Champlain basin. All these cases were arranged by Miss Goldring, and the material for the latter collected at her own expense in New York, Vermont and the provinces of Quebec and Ontario. These recently extinct Pleistocene fossils from the salt-water deposits bounding the ancient Hochelagan sea which preceded Lake Champlain, are displayed in such a manner as to bring out not only the perfection of the material, but to indicate that these marine shells decreased in size, thickness and number as one goes southward from the St Lawrence region where the waters of the sea were deepest and of maximum salinity. Where the fresh waters flowed freely into this ancient sea at the south, the species decreased in size and number, so that the marine life seems practically to have become extinct at the latitude of Crown Point, while the waters of this narrow sea extended still farther south, though too diluted in their salinity to support the existence of these animals.

Some additions have been made of restorations in the paleontology exhibits. The Museum has received by gift a restoration of

one of the largest of the fossil fishes, *Dinichthys*, made by Dr L. Hussakof and presented by the courtesy of the American Museum of Natural History. Mr Marchand has created some additional models of graptolites, and Mr Hartnagel has now finished the special exhibit of fossil corals.

In the zoology hall some noteworthy additions have been made to the exhibits, among which may be mentioned the installation of the New York fishes received from the Conservation Commission; an exhibit of the tree toad, designed to show protective coloration; new groups representing a family of woodchucks; and a section of a sand bank with nesting bank swallows. The collection of domestic pigeons has been enlarged, and an effort has been made to present a representative collection of the mollusks of New York. The Museum owns a very large series of the New York mollusca, but the limitations of the Museum hall have thus far permitted the display of but a small portion of this collection. The corals and other low invertebrates have been installed so far as the available space permits, and a series of cases has been devoted to the display of the birds' eggs and nests, the collection which has been considerably augmented by the acquisition of the series brought together by the late Martin J. Conway of Troy.

A special illustration has been made of the sea fowl nesting in the greatest of the remaining colonies of these birds, Bonaventure island in the Gulf of St Lawrence. These are all representatives of New York species. Quite recently a very important addition has been made to the Museum by the gift from Benjamin Walworth Arnold of Albany, of his entire collection of eggs and nests of birds, upon the assembling of which he has been engaged for the last forty years. Mr Arnold's collection is very large, and represents about 1000 species of birds from North America, and several hundred additional species from South America, the Falkland and other South Atlantic islands, Africa, Australia and Europe. This Arnold collection is one of the very largest in the possession of any public museum in this country, and its acquisition therefore makes of necessity this Museum a headquarters for students of ornithology. It is planned to instal this collection in part along the west corridor into the zoology hall where it will not be exposed to the direct sunlight, and so in a large measure be protected from fading.

The zoological division is insufficiently manned. So many special lines of interest are represented here that it is difficult for one man, however expert, to handle them all. The present zoologist is active and efficient, but he is without adequate assistance, and

the growing importance of his work makes it imperative that he should have more help. In its present equipment the zoology division does not balance with the other divisions of the Museum, and with the burden of work which the division presents, practically no time is permitted to the zoologist for scientific investigations.

The collection of reproductions of edible and poisonous fungi, contemplated in the last report of the Director, has now been completed to its present possible limits. Fifty-nine reproductions in specially prepared composition, have been made by Mr Marchand and are temporarily installed in the end room of the east mezzanine. They will eventually be displayed more centrally in the rotunda, between the corridors, where their extraordinary workmanship will be more effectively presented. Doubtless this collection should be increased in size, although it now includes the most obvious edible species and a few of the noxious forms. It is hoped that the presentation of this illustration of fungi may encourage a closer familiarity with this important source of nitrogenous food. But very few species growing in this State are poisonous. The great majority are edible, at least by most people. It happens, however, that the most poisonous species are often the most striking and attractive, and it is quite essential that gatherers and eaters of mushrooms should recognize these noxious species first of all.

It has not thus far been possible to make an effective installation of the botanical collections. Botanical material seldom lends itself to public display, and though the herbarium of the Museum is of a very large size, it must of necessity be kept in the background. There is very little room in the Museum at present that can be utilized for such botanical exhibit. The woods of New York have been arranged in the botanical room in the east mezzanine, and it is planned to introduce there or elsewhere in the Museum a display of reproductions of the pharmaceutical plants of New York. This display, if effectively rendered, should be of distinct educational value.

The west mezzanine room, which is continuous with the Iroquois floor, has hitherto been used for lecture purposes and temporary exhibits. As the Museum needs a place for lectures, not far away from immediate association with the exhibit halls, it has been found convenient to utilize this for such purpose, even though its seating capacity is small. The room is still reserved for this use, but its walls have been utilized for the purpose of displaying a series of

the geological maps of the State and parts thereof, and also for showing the various certificates, diplomas and medals of award that have been received by the Museum at the various national and international expositions.

During the past year the heroic statue of Professor Joseph Henry, which had been for some years standing in the rotunda of the Capitol, and which was modeled by the sculptor John Flanagan for use at the St Louis Exposition, has been removed to the Museum halls, its broken condition repaired, the surface suitably bronzed, and the statue placed in a commanding position in the rotunda. Alongside of it is attached a frame carrying parts of simple electrical instruments devised and used by Professor Henry for his fundamental experiments on electrical transmission and induction, made while he was a teacher of mathematics in the Albany Academy in the years 1827-32.

With the present tremendous development of electrical science and its application to a great diversity of human comforts, Professor Henry's fundamental work is just coming into the fulness of its recognition. As he was a native of the Albany district, a resident of this city for most of his younger years, and a teacher in one of the Albany schools, it has seemed very proper that measures be taken for a memorial here to the service he rendered to humanity. A campaign has therefore been undertaken for the purpose of raising funds to put this fine model of Henry into bronze. This canvass has been reasonably successful and the amount raised, it is believed, will be, with the cooperation that has been promised, sufficient to erect this memorial, which is to be placed in the city park well in front of the venerable Albany Academy building, permission for this having already been granted by the city council.

In Lincoln Park, one of the municipal parks of Albany, stands a low, red brick building which was built by James Hall, the late State Geologist and Paleontologist, about the year 1856, and which from that time until his death in 1898, served as the laboratory where his geological investigations were carried on, and where were kept the great collections of geological material belonging to himself and to the State. At the time it was built, Professor Hall had no other official headquarters. He had chosen a place well outside of the settled part of the city, and lived in comparative isolation, surrounded by his scientific materials and his scientific assistants. From 1856 to 1886 all the work of the Geological

Survey was done in this building, and from this laboratory were graduated many geologists who afterwards attained distinction in the science, among whom may be mentioned Ferdinand V. Hayden, director of the United States Geological Survey; William M. Gabb, state geologist of California; Fielding V. Meek, United States geologist; Robert P. Whitfield, paleontologist; Charles D. Walcott, director of the United States Geological Survey and present secretary of the Smithsonian Institution; Charles E. Beecher, professor of paleontology, Yale University; Charles Schuchert, professor of historical geology and paleontology, Yale University. In the building were written not only the volumes of the Paleontology of New York, various geological reports of New York issued during those years, but also reports on the geology of the states of Wisconsin, Iowa and Ohio, and various government scientific expeditions; the Mexican boundary survey, the Pacific Railway survey, the Stansbury expedition, etc. For a generation the influences which emanated from this building were the most potent factor in the development of American geology, and in recognition of this fact, now that the building has become the property of the city and is used for purposes connected with the maintenance of the Lincoln Park, it has been decided by the Association of American State Geologists to perpetuate its associations by placing thereupon a commemorative bronze tablet. The money has been provided for this purpose and the tablet will be presently erected. We have received from the commissioner of public works of the city of Albany the assurance that the building will be maintained intact in perpetuity.

The field meeting of the Association of American State Geologists. By the desire of the officers of the association, the annual field meeting of the official geologists of the States was held under the auspices of the Museum in September. The association was represented by a party of about thirty-five, which included several representatives of the United States Geological Survey. In spite of rather forbidding weather the field meetings were instructive and satisfactory. The first day was given to a trip by automobile into the classical Paleozoic sections of the Helderberg mountains, the Indian ladder, with its succession of formations, and from there upward the geological series was followed along the outcrops through Thompson's lake and on by Warner lake, into Knox; thence, on returning, the geologists were entertained at Altamont at the home of Mrs John Boyd Thacher, the

donor of the Helderberg escarpment to the State (John Boyd Thacher Park). On the following day the party went to Saratoga Springs to examine the mineral springs and their relation to the Saratoga fault. From the state reservation there a visit was made to the Cryptozoon ledge, or Lester Park, returning in time to arrive at Port Henry that evening. The following day a visit of inspection was made to the iron mines at Mineville, and by courtesy of the Witherbee Sherman Company the visitors were given every opportunity to descend into the mines and see the underground as well as the surface workings in every detail. The afternoon of the same day a walking trip was made from Port Henry northward along the shore of the lake where brilliant and instructive exposures were shown of the Grenville limestone with its contorted inclusions. Leaving that evening for Port Kent, the early part of the following day was spent in the Ausable chasm at the mouth of which automobiles met the party and took its members to the Champlain Club of the Catholic Summer School at Cliff Haven, the road thus passed running over the dissected deltas of the Ausable and Little Ausable rivers. At Cliff Haven the geologists were the guests of the school by invitation of the Rt. Rev. Mgr. John P. Chidwick, and here they were most agreeably entertained. After examination of the very interesting geological phenomena upon and about the grounds of Cliff Haven, the party was met by Prof. George H. Hudson, who carried them by boat to Valcour island. Under Professor Hudson's guidance the interesting geological structures of Valcour island were exploited and the evening of the day was most agreeably spent at Professor Hudson's camp on the island. Late at night the visitors returned by boat to Plattsburg and left thence in the early morning for Burlington, Vermont, where, under the guidance of Prof. George H. Perkins, opportunity was given to visit striking geological developments in the vicinity. There the party disbanded.

Meeting at Albany. By invitation of the president of the University, the Geological Society of America, the Paleontological Society, and the Association of American State Geologists held their annual meetings in Albany during the week beginning December 25, 1916. These meetings brought together a large number of geologists, perhaps the largest ever gathered here, and they continued through the week. The comfort of the visitors was studied in every regard and an effort made to give the sessions the assurance of success. At these sessions the Director of the Museum acted as president

of the Geological Society of America, and Dr Rudolf Ruedemann as president of the Paleontological Society.

The New York State Archeological Association. The activity of the Archeologist of the Museum has resulted in the organization of a state society devoting itself to the scientific collection of aboriginal relics and the protection of aboriginal monuments. Its fundamental purpose is to prevent, so far as possible, the destruction and scattering of these records as well as the desultory and indifferent preservation of them. Several field meetings of the association have already been held, and one vigorous chapter organized in the city of Rochester. It is planned that other local chapters will be formed as the local interest in archeological studies develops. The relation of the Museum to this association is that of parent organization, and under the present form of organization the State Museum is the authorized headquarters. Doubtless the influence and the benefit of the Museum and the local societies will be mutual and efficient.

Museum lecture course. The course of free public lectures was instituted during the winter of last year, all of which were on topics closely related to the activities of the Museum, and all were presented by members of the Museum staff. As an illustration of the character of this course, the following list of the topics presented is here given:

- 1 The State Museum—How to Use It
- 2 Diamonds
- 3 The Forests of New York State
- 4 Lake Albany, Our Present Abode
- 5 Man and Insects
- 6 How Minerals Are Formed
- 7 Mastodons and Elephants of New York
- 8 The Empire State of Indian Days
- 9 Harmonics and Cross Purposes in the Insect World
- 10 Earthquakes of New York
- 11 Nature Monuments
- 12 Life of the Ancient Seas

These lectures were well attended, usually to and sometimes beyond the capacity of the Museum lecture room. The public interest in them justifies the continuation of this undertaking.

Dedication of the New York State Museum. Although the New York State Museum at Albany has been open to the public for some months past, it seemed wise to the Regents of the Uni-

versity to bring the public into closer touch with the new Museum by formal dedicatory exercises. These took place in the Chancellors Hall of the Education Building at Albany on the afternoon and evening of Friday, December 29, 1916. The afternoon exercises consisted of a series of addresses from eminent speakers, each representing a special phase of community interest in the Museum. The Hon. Charles B. Alexander, chairman of the Regents committee on the State Museum, presided, and the speakers were President John H. Finley on behalf of the University and the educational system of the State, Senator Henry M. Sage on behalf of the state government. Dr Francis Lynde Stetson on behalf of the people, the Hon. Charles D. Walcott, speaking as a representative of science in its broadest sense, and Director John M. Clarke on behalf of the Museum. In the evening the principal address was by Colonel Theodore Roosevelt, who spoke under the title "Productive Scientific Scholarship," and gave an extraordinary and illuminating speech to a colossal audience. Colonel Roosevelt was introduced by Governor Charles S. Whitman, who very happily set forth the value of the research work of the scientific corps attached to the Museum. The evening exercises were felicitous and successful throughout, and were followed by a reception in the halls of the Museum. Colonel Roosevelt's address on this occasion, or the part of it that related especially to his scientific theme, has been already printed in "Science," and all the addresses of the occasion have been published together as a bulletin of the University.

III

CONDITION OF THE SCIENTIFIC RESERVATIONS
BELONGING TO THE MUSEUM

Since the publication of the last report of the Director, the Museum has acquired by the gift of Mr Emerson McMillin, of New York, the property known as the *Northumberland volcano*, or *Stark's knob*, situated 2 miles north of Schuylerville. An account of this interesting geological spot has been given in previous reports of the Director, and its structure fully illustrated up to the present state of our knowledge. This gift rescues from certain oblivion what is to New York, and perhaps in a broader sense to geological science, a unique phenomenon. The place is easily accessible to travelers on the road leading from Schuylerville north along the Hudson river, and as the volcanic core is now cut in half by quarry operations, which the gift has happily forestalled, its intimate structure is instructively revealed. This knoll of volcanic rocks has a historic interest because of its association with the Battle of Saratoga and the erection thereupon of the battery by General John Stark.

Of the three properties now under the control of the State Museum — the Clark Reservation near Jamesville, the Lester Park west of Saratoga Springs, and the Stark's Knob Reservation, only the Lester Park is well protected and satisfactorily monumented. In the case of the Clark Reservation, the donor has been pleased to construct an elaborate and attractive entrance, built of blocks of local limestone, which in the piers of the gateway are of very large dimensions. Otherwise this reservation is without protection. Its line fences are in large measure down, and some of its boundaries, being new lines, have never been fenced at all. As public property the place is rather more exposed now to the stealing of timber and the vandalism of collectors of rare ferns than it ever was before, and while, through the kindness of the benefactor, we have rescued the place from commercial invasion so far as its effective landscape scenery is concerned, we are failing to defend it against the attacks of marauders. It is further to be said that no provision has been made for the accommodation of visitors by the laying out of paths or building stairways, one of

which, down the face of the cliff to the waters of the lake, is quite imperative for safety's sake. The condition of the place is such that it has been necessary to post notices to the effect that visitors are in the reservation at their own risk, and this has been done in order to defend the State against any liability. It is foreign to the purpose of these reservations to turn them into public parks. They have been set aside in order that they may be preserved, but it is obvious that we are failing of our duty in respect to the proper treatment of the Clark Reservation.

This is also true of the more recently acquired Stark's knob. No boundary fences have been set up about this property and its original condition as transferred to us has not been modified.

For successive years requests have been made for modest appropriations to cover these justifiable expenses, but up to this time nothing has been allowed.

In view of the fact that the State has in many instances accepted private properties of real estate for public park uses, as in the case of the gifts by Mrs John Boyd Thacher of the Thacher Park in the Helderberg mountains, of the late William Prior Letchworth of Letchworth Park on the Genesee river, and Mrs E. H. Harri-man of her large properties, and has in recognition thereof made annual or regular contributions for their upkeep and maintenance, it seems an untoward attitude to deny the modest provision necessary to keep these Museum properties in proper condition on the basis of the somewhat ungenerous argument that whoever is to give such private properties to the State must also provide for their care and maintenance.

IV

DEPARTMENT PUBLICATIONS

During the year the bulletins of the Museum have been issued as rapidly as circumstances permitted. They have the following numbers and titles:

- 181 The Quarry Materials of New York. By D. H. Newland
- 182 The Geology of the Lake Pleasant Quadrangle. By William J. Miller
- 183 Glacial Geology of the Saratoga Quadrangle. By James H. Stoller
- 184 The Constitution of the Five Nations. By A. C. Parker
- 185 The Precambrian Rocks of the Canton Quadrangle. By James C. Martin
- 186 31st Report of the State Entomologist 1915. By E. P. Felt
- 187 Director's Report for 1915
- 188 Report of the State Botanist for 1915. By H. D. House
- 189 Paleontologic Contributions from the New York State Museum. By Rudolf Ruedemann

The State Museum Bulletin is now issued as a regular monthly periodical. This arrangement holds back in some degree the number of reports which can be issued in any one year, as it seems impracticable with the present service to issue more than one a month, while it might be possible for the staff to prepare more than twelve a year.

The Wild Flowers of New York. Under provision of the Legislature the preparation of this monograph has gone forward with entire success, and the detailed account of its present condition will be found in the report of the State Botanist. It is believed now that all the necessary color plates for illustration have been taken and the preparation of the text for these volumes is advancing favorably, so that publication may perhaps be expected within another year.

Birds of New York. The demand for this work still continues. The supply of the quarto Memoir volumes is very greatly reduced, and these books can not be much longer supplied. The first edition of the portfolio of colored plates, 16,759 copies, has been exhausted, and by agreement with the Comptroller a second edition has been printed to the number of 10,000 copies, each copy of these being held for sale under this agreement at the price of \$1, transportation paid.

V

CONSIDERATIONS FOR FUTURE GROWTH OF THE
MUSEUM

The Director in previous reports and on many occasions has set forth the conception of the central State Museum as pictured by the statute, and has failed of no opportunity to present the claim of the statute to the attention and consideration of the people and their representatives. Constant dropping will wear away the hardest stone; constant reiteration may eventually effect the purposes of the law. It has been a source of gratification to find the expressed purpose of the statute as so often and so urgently presented, indorsed by the speakers who participated in the dedicatory exercises at the formal opening of the Museum.

Senator Henry M. Sage said:

It is hoped that its [Museum's] growth will finally include collections of every kind which have an educational value to the people of this State. The "chariot is hitched to a star," and yet no great thing has ever been accomplished without ambition seemingly impossible of fulfilment.

Dr Francis Lynde Stetson said:

So for our own people, this generation as well as its successors, wise provision is needed and also wise provision, and the people of the State of New York need, even though they may not know it, the creation and nourishment of public museums of art and of science and in particular their own museum, in this capital city.

Mr Theodore Roosevelt said:

I warmly sympathize with the ambition expressed in your annual report to have this Museum more than a mere scientific museum. It should be a museum of arts and letters as well as a museum of science.

The science museum in its present development constitutes a unit in the museum scheme. The development of the additional units must be a matter of slow growth, but it is not necessary to wait for the development of these additional units in the central State Museum in order to validate the provisions of the statute which give to the central Museum control, the same advisory and inspection functions as are given to the State Library in its attitude

toward local libraries. The State Museum stands in the law with this positive and well-defined function; supervisory affiliation with local museums supplemented by power to grant public moneys for the encouragement and maintenance of such local museums. It may be said that the effectiveness of this provision is fully contingent upon the willingness of the Legislature to make money grants for the specified purpose. This, however, is a secondary reason. The primary reason lies in initiative in approaching the Legislature for this purpose in order to carry out the expressions of the statute.

VI

REPORT ON THE GEOLOGICAL SURVEY

In the last season the Director was obliged to take a large personal risk in order to continue field operations of an important character, because of the failure of adequate provision for this purpose. Only the well-worn appeal to the loyalty of some of the more patient members of the geological staff and the generous disposition of others in deferring immediate compensation for their work has made this active field service possible.

AREAL GEOLOGY

In the work directed toward the completion of the great geological map of the State on a scale basis of one mile to the inch, considerable progress was made in the Adirondack region by Prof. H. P. Cushing, Prof. W. J. Miller and Prof. C. H. Smyth, jr, who was associated in the field operations with Dr A. F. Buddington.

The geology of the Gouverneur quadrangle was in part reported upon last year. Professor Cushing's report on his later operations follow:

The Gouverneur quadrangle. With the exception of scattered patches of Potsdam sandstone, most of them very small, the entire area of the quadrangle is occupied by Precambrian rocks. Early Paleozoic sediments seem to have once covered the entire quadrangle and to have been entirely removed by erosion except for these Potsdam remnants. This sandstone was deposited on the worn and irregular surface of the crystalline rocks and the patches which remain are those portions of the sand which were deposited in the deeper depressions of the old surface. Such depressions were substantially in all places where limestone was the surface rock, and all the patches which remain rest upon limestone. In many of them a small thickness of conglomerate is found at the base of the sandstone, the angular pebbles having been derived from the thin bands of quartzite in the limestone. The sandstone is either red or gray in color and for the most part very thoroughly indurated. It was deposited on sloping surfaces, for the most part, and its dips rudely conform to these slopes. Locally the limestone surfaces were intersected by joint cracks which had become widened by solution, these became filled with sand, and such sand-filled cracks still remain in places where the remainder of the sandstone has been entirely worn away, and appear like dikes

cutting the limestone. A notable instance of the sort occurs at Halls Corners (Rock Island School).

As is the rule in northern New York, the Precambrian rocks comprise the sedimentary Grenville series and various later intrusives. Though the igneous rocks occupy somewhat more than 50 per cent of the area of the quadrangle, it is nevertheless probably true that the Grenville rocks have greater areal extent here than in any other quadrangle in northern New York. Particularly impressive is the great belt of Grenville limestone which stretches all the way across the quadrangle from northeast to southwest, much of it very pure limestone. Toward the northeast it becomes impure and belts of other Grenville rocks wedge into it; but along the west margin of the quadrangle it has a breadth of some 8 miles, 5 miles of which is pure limestone. As Smyth long ago pointed out, it is the longest and broadest belt of Grenville limestone in New York. A large quarry industry has long been based upon it.

The larger part of the impure limestone of the quadrangle consists of alternating beds of limestone and quartzite. Where the quartzite bands are few and thin the stresses to which the rocks have been subjected have resulted in the fracturing of the brittle quartzite bands and the indiscriminate mingling of the fragments with the general mass of the limestone, giving a rude resemblance to a conglomerate. Such pseudo-conglomerate alternates with thicker bands of quartzite. One very prominent band of alternating limestone and quartzite enters the quadrangle from the south at Sylvia lake and runs east-north-east to Edwards. It is of especial importance because of the talc deposits that occur within it, and a line of openings for this mineral marks the course of the belt across the quadrangle. Because of this it has been given a separate coloration upon the map; at the same time it must be understood that there is always some quartzitic material in the belts which are mapped as limestone.

Aside from the limestone and the quartzite the Grenville rocks comprise a great variety of schists, hornblende schists, mica schists, red to green calcareous pyroxenic schists, garnetiferous gneisses and pyritous gneisses, together with many other less common varieties. For the most part these varieties of gneiss and schist are sufficiently distinct and of easy enough identification to warrant their separate mapping were it not for the fact that they commonly occur interbanded with one another in such thin beds as wholly to preclude their mapping, except upon a very large scale.

In general also thin bands of limestone and of quartzite are interbedded with them. It therefore becomes necessary to map the whole complex as Grenville schist in the majority of cases. It is only in exceptional instances that any one of these rocks occurs in sufficient bulk and sufficiently free from admixture with the other varieties to warrant separate mapping. Within the Gouverneur quadrangle are two belts of hard, mica gneiss, usually garnetiferous, which have received separate mapping. One of these belts enters the quadrangle near its southwest corner, and has been traced for 12 miles when it is apparently cut out by granite. Another and still broader belt occurs in the southeast part of the quadrangle, and only a small part of its mass lies within the quadrangle's limits.

There is considerable of the rusty, pyritous gneiss, which is such a characteristic Grenville rock, within the quadrangle but in such thin beds that separate mapping is not practicable. One such belt wedges up within the limestone just west of Gouverneur and thence runs continuously clear across the quadrangle and beyond. A number of openings for pyrite have been made along it and the Stella mine at Hermon, just without the quadrangle's limits, is still active. But the rusty gneiss is simply a thin, uppermost bed to a belt of hard, fine-grained gneiss and coarser mica gneiss interbedded in the limestone, too thin to separate from them in mapping. Another thin band of the rusty gneiss overlies the limestone belt which comes into the quadrangle on the west side of Sylvia lake, lying between the limestone and the gabbro which borders it on the west and north.

The Grenville rocks across the quadrangle have a general northeast strike and northwest dip. The mapping clearly brings out the fact, however, that the structure is not that of a simple monocline but consists of a series of closely compressed and overturned folds; in other words, that it is isoclinal. Southeast dips occur here and there, but only locally. The dips are in places very flat, elsewhere so steep that they are nearly or quite vertical. At one stage in the work it was hoped that one limb of a fold would prove to have a steeper dip than the other limb, and that this might give aid in working out the structure; but no such relation could be demonstrated. Many of the folds, probably all of them, have a decided pitch, but in the vast majority of cases it can not be determined whether the pitch is to the northeast or the southwest; in other words, whether the structure is anticlinal or synclinal.

Locally many variations in direction of strike occur, and there is especially manifest a tendency on the part of the sediments to wrap around the ends of the sills of igneous rocks.

The igneous rocks of the quadrangle consist of gabbro and of two different granites. The gabbro is much older than one of the granites and is probably older than either, though its time relation to the older of the granites can not be definitely ascertained. It is everywhere highly metamorphosed and converted into the hornblende-feldspar rock called amphibolite for convenience. In its marginal phases it is always a thoroughly foliated hornblende gneiss or schist and can not be distinguished from similar gneisses which are interbanded with the Grenville sediments and form a characteristic constituent of that series. But in the larger masses more solid, less metamorphosed cores are always present whose igneous origin is clearly apparent. In the southeast half of the quadrangle there was originally a large mass of this gabbro but it has been badly cut up and cut out by the later of the two granites, and now occurs in a number of disconnected masses.

Of all the rocks of the quadrangle this gabbro was the most susceptible to attack by the granite. Its marginal portions are always full of masses of pegmatite and of quartz either as dikes or as lenticles; and in addition there has also been much minute penetration and soaking of the gabbro by the granite. Wherever the two rocks adjoin there is apt to be a gradual passage from the one rock into the other, no sharp boundary separating them can be drawn, and to discriminate between granite-cut gabbro and granite with plentiful gabbro inclusions is no easy matter. More rarely, however, the boundary is quite sharp.

The gabbro occurs in part in more or less oval masses which plainly either wedge aside or else cut out the sediments and whose intrusive nature is therefore clear; and in part in long, narrow bands which probably represent sills and whose intrusive nature is much more difficult to demonstrate. The long, narrow belt of gabbro which lies just east of Moss ridge and whose prolongation is associated with the rusty gneiss of the Stella pyrite mine at Hermon, is mostly thoroughly gneissoid and the proof of its igneous nature is very difficult to obtain, though rather massive rock may be obtained from within it at various places. Smyth shows a disposition to regard it as an igneous rock at the Stella mine occurrence, and my study of the whole belt leads me to the same conclusion,

though with the candid admission that certainty is unattainable in the matter.

The only representative within the quadrangle of the old granite gneiss which I correlate with the Laurentian granite of Canada is the oval mass or stock, comprising some 7 square miles in areal extent, which lies directly north of the village of Gouverneur. In its thorough conversion to orthogneiss with evenly granular texture and its abundant inclusions which are invariably of amphibolite, it conforms wholly to the type of this earliest granite and is quite distinct from the remainder of the granite of the quadrangle. Though the mass is small it lies only a short distance from, and is really the northeast prolongation of, a large mass of this granite which the railroad cuts across all the way from Keene to Philadelphia and which forms what I have called the Antwerp batholith in reporting upon the Theresa quadrangle. This stock at Gouverneur is entirely surrounded by limestone, into which it sends dikes; hence it is impossible to determine its time relations with the gabbro and the other granite.

The younger granite of the quadrangle is a porphyritic granite which is precisely like the porphyritic granite which in many localities in northern New York occurs as a border phase of the augite syenite of the region, so that I have no hesitation in correlating it with that rock. It shows many phases, sometimes being very coarsely porphyritic, sometimes being fine grained and with little trace of porphyritic texture. The smaller bodies of the rock are most apt to be fine grained, and the larger masses are often of similar grain marginally; but there is much variation in the different masses, and from place to place in the same mass. Where the granite cuts gabbros broad zones of mixed rock are often produced, in the manner just described, injection gneisses, soaked zones, and a host of pegmatite and quartz veins. Where Grenville rocks are cut the granite sends occasional dikes into them and holds occasional inclusions of them, but the Grenville rocks are little affected by the intrusion except locally. Some very large Grenville inclusions are found in these granites, often large enough to be mapped, and several of these are of limestone. In this respect this granite contrasts strongly with the older granite in which the inclusions are always of amphibolite.

The most unusual feature attaching to the porphyritic granite is its manner of occurrence, in a series of subparallel, long, narrow tongues, which conform to the bedding of the adjacent sediments

and which seem to be sills. This type of occurrence is unusual in northern New York, in which the igneous rocks occur usually in batholiths, stocks and dikes, and I have met with it only in this immediate region. When the mapping shall have been extended over the southeast part of the quadrangle it may prove that these sills are merely outlying members of a batholite of granite or syenite which occurs there. If not that then, in all probability, they indicate the presence of a batholite at no great depth below the present surface. Evidence has been forthcoming in the Thousand Islands region, in the case of the Picton granite, that the present surface exposures of the batholite are of its very roof. The occurrence of these granite sills on the Gouverneur quadrangle, and on the Ogdensburg and Lake Bonaparte quadrangles just north and south also, sills which have with little doubt been given off from a larger mass of probable batholic nature, is additional evidence that in this northwestern region erosion has not cut deeply into the Precambrian rocks; and the large amount of the Grenville series which still remains, in contrast to the region farther east, is indicative of the same thing. It is becoming quite clear that there is a sharp contrast between this region and the general Adirondack region in this respect; that the general altitude of the former has been less than that of the latter, as it is today; that it has been less subject to considerable uplift; and that as a result erosion has bitten far less deeply into the Precambrian rocks of the Gouverneur region than into those which lie more to the east.

Lake Placid quadrangle. Professor Miller, who is completing the survey of this region for a joint report thereon by Professor Ruedemann and himself, makes the following statement:

A prominent belt of coarse, often porphyritic, granite extends across the northern portion, and extensive areas of the Whiteface type of anorthosite lie just south of the granite. Two considerable areas of Grenville gneisses with some limestone occur, one near Franklin falls and the other between Catamount and Wilmington mountains.

Between 1 and 2 miles west of East Kilns a large mass of rock was discovered which quite certainly has resulted from the assimilation of anorthosite by syenite (and possibly granite) magma, the evidence for this mode of origin being well shown in good outcrops.

A feature of particular importance is the occurrence of parallel, narrow dikes of basic rock cutting the coarse granite on Cata-

mount mountain and on the small mountain between 1 and 2 miles north of East Kilns. These dikes are holo-crystalline and mostly badly weathered. They are quite different from any dike rocks hitherto observed by the writer in the Adirondacks.

Catamount mountain exhibits a remarkable variety of rocks. Within a single square mile from the base of the mountain to the summit, the following rock types are well exhibited: Grenville gneisses and limestone, Whiteface anorthosite, coarse granite, syenite, granitic syenite, aplite dikes, gabbro stock, basic (norite?) dikes, pegmatite dikes, diabase dikes and quartz veins.

Schroon Lake quadrangle. For this quadrangle Professor Miller reports that the Precambrian rocks comprise anorthosite, Whiteface anorthosite, syenite, granite syenite, granite, gabbro, pegmatite and diabase.

A feature of particular importance is the outlier of Paleozoic strata in the vicinity of Schroon Lake village. Several large outcrops of Little Falls (?) dolomite occur in and near the village. A small area of Potsdam sandstone was discovered one and one-half miles southwest of the village, but most of the Paleozoic strata are concealed under Pleistocene deposits.

In the central portion of the quadrangle, a zone several miles wide, between the great body of anorthosite on the north and the syenite-granite series on the south, exhibits a very mixed lot of rocks, one type which frequently appears being almost certainly an assimilation product between anorthosite and syenite-granite magma.

Lake Bonaparte quadrangle. The field work on this area has been carried on by Doctor Buddington under the direct supervision of Prof. C. H. Smyth jr. They report as follows:

The results of the survey in 1916 are, in all essentials, confirmatory of the conclusions regarding this district based upon brief reconnaissances made by the senior author in 1894 and 1897. A detailed report on the region is now in course of preparation, although not yet far enough advanced to warrant more than a slightly modified restatement of the previous conclusions. The dominant trend of the formations is from northeast to southwest throughout the quadrangle. The prevailing strike of the gneissic and cleavage structures is likewise northeast with a variable steep dip to the northwest. The region may be considered in a broad way as comprising three bands of different geological characteristics. The entire southeastern half of the district is formed by

a great mass of banded differentiated syenitic rocks, varying in a very broad way, from a normal augite syenite with more basic bands, through a more siliceous red hornblende grano-syenite (interrupted by bands of a more basic or more siliceous character) to a hornblende biotite granite which sends off numerous dikes. Occasional dikes of hyperite with an ophitic texture cut the syenites.

The central band, about 4 miles wide, comprises a belt of Grenville gneisses and marble intruded by sheets and bosses (for the most part parallel to the cleavage or bedding) of gabbro, syenite and granite, the latter usually a coarse porphyritic type. The gneisses are the usual biotite, pyroxene, garnet, sillimanite and rusty gneisses characteristic of this formation. South of Lake Bonaparte the Grenville gneisses are intruded by an elliptical shaped mass of fine-grained red granite.

The northwestern band is a rock complex consisting of (1) an elongated intruded mass of fine-grained granite partially overlain and completely surrounded by a narrow belt of garnet gneiss with thin beds of intercalated marble; (2) two masses of gray quartz biotite gneiss intruded by sheets of porphyritic granite and more or less abundant pegmatite veins parallel to the cleavage, one mass wrapping around the granite-garnet gneiss belt on the southeast and northeast, the other intruded by a small mass of porphyritic granite and forming the whole northwest corner of the district; (3) a narrow tongue of marble and white quartzite beds overlapping on this quadrangle from the Gouverneur district. The garnet gneiss is a mixed rock formed by intimate injection of Grenville gneiss by pegmatite veins. On the northwest side of the granite mass it possesses a low undulatory dip in general about 30° northwest, while on the southeast side of the granite it dips vertical to steep northwest indicating the possibility of an asymmetrical fold slightly overturned toward the southeast. The quartz biotite gneiss is presumably igneous, but of doubtful origin. It contains inclusions or residuals of gabbro but is granitic in composition. Like the garnet gneiss, the northwest area dips low northwest while that on the southeast side of the granite-garnet gneiss belt dips steep northwest beneath the garnet gneiss.

Indications are that the mode of intrusion of the porphyritic granite has been dominantly by pushing in along cleavage or bedding planes, and to a minor extent by brecciation. In one case, the gabbro similarly forms an almost continuous belt about 14

miles long and not over one-half of a mile wide and must be sill-like in nature. The northwestern mass of fine-grained granite is now being exposed by erosion of a domed series of overlying beds of Grenville gneiss, while the strikes of the beds around a similar mass of fine-grained granite south of Lake Bonaparte are parallel to its border.

The syenite bears intrusive relations to the gabbro, while the syenite itself is intruded by granite dikes offshooting, presumably from the porphyritic granite, from the fine-grained granite, and from its own granitic differentiate as the case may be.

Four small patches of Potsdam sandstone remain as outlying remnants within the central belt of the Grenville series, resting unconformably on the lower eroded levels of the marble beds.

Thoroughgoing cataclastic metamorphism of a portion of the syenite mass, as well as of dikes of hyperite and granite cutting this mass whose cleavage is parallel to that of the inclosing rock, together with the regional trend of the formations, shows unmistakably the evidence of intense, long-continued orogenic forces previously acting in this region. The minor evidence of cataclastic structures in the Grenville gneisses may be partially explained by subsequent igneous metamorphism. A possible variation in the effect of these forces distributed according to the geographical location and character and age of the rock is being investigated. Other important data with respect to the gneissic structures will be given later.

SURFICIAL GEOLOGY

The glacial phenomena of the Catskill mountains. The investigation of the glacial geology of the Catskills was begun during the past summer by Dr John L. Rich, and included a reconnaissance of the region as a whole and a semidetained mapping of its glacial features directed toward the outlining of the major events of its glacial history and a determination of the problems for whose solution more detailed examinations might be required.

All the higher mountain region, except a small section south and southwest of Arkville, was studied, and, in addition, reconnaissance surveys were carried down the west branch of the Delaware river to Delhi, thence up the little Delaware to Lake Delaware, and also south of the mountains into the upper branches of Neversink and Rondout creeks. The area examined included the whole of the Phoenician and the mountainous parts of the

Kaaterskill and Durham quadrangles besides parts of the Gilboa, Hobart, Delhi, Margaretville, Neversink, Slide Mountain and Rosendale quadrangles.

Within this area, all the principal valleys and those of all but a few of the smaller tributaries were examined. Almost all the surface was seen from a greater or less distance.

Types of glacial deposits. On account of the prevailing rugged relief of the region, the glacial deposits, with the exception of the ground moraine or till, are rather strictly limited to the valley bottoms and lower slopes and are absent, or very weakly developed, on the steeper slopes. To trace moraines from one valley across the intervening ridges to another is, therefore, commonly difficult or impossible, hence the correlation of moraines in adjacent valleys can not always be made with certainty by this means.

The types of glacial drift distinguished on the map include till, thick nonmorainic drift, drumlins, kames, eskers, and glacial lake and outwash deposits. Smooth-topped deposits of thick nonmorainic drift proved to be widespread. They differ from moraines in that the characteristic irregular topography and looped form are lacking. In many places they seem to have been formed by the accumulation of débris beneath the ice, and there are all gradations to typical drumlins. Elsewhere they prove to be glacial deposits of various kinds which have been overridden and smoothed by advancing ice. In the upper Schoharie and the Esopus valleys many such smooth-topped deposits were found to be stratified lake clays, sands and gravels covered with a veneer of till.

The drift filling in the valleys is surprisingly deep. Borings by the New York City board of water supply have established the fact that the rock beds of Schoharie creek and its tributaries in the vicinity of Prattsville lie, roughly, 200 feet below the present beds of the streams. Much of the filling in that vicinity consists of stratified glacial lake clays, but in most places there is a veneer of till on the surface.

Glacial movements. At the time of its maximum extension, the ice of the continental glacier appears to have completely buried the Catskills, with the possible exception of a few of the highest peaks. The highest definite striae were found on the west spur of Slide mountain at an elevation of 3580 feet, but compact, stony soil, indistinguishable from glacial till, was found at 4030 feet on Slide mountain and at 3900 feet on Hunter mountain. No conclu-

sive evidences either for or against glaciation were found at higher elevations on these or other mountains. In general, it is very difficult to find evidences of glaciation at elevations above 3000 feet, partly because erratic boulders of rocks foreign to the region are very rare except opposite the passes on the north and east borders of the mountains.

The striae at the higher elevations all indicate a general southwestward movement of the ice across the region. The direction of movement ranged, in different places, from south to S. 45° W. About S. 20° W. is the dominant direction. At lower elevations, the striae indicate much greater diversity of movement.

During the retreat of the ice front across the mountains, the series of events was complicated by the fact that the movements of the marginal portion of the ice were strongly influenced by the broader features of the topography, and, further, by the development of local valley glaciers whose deposits are not everywhere easily distinguished from those of the continental glacier. The possibility that important readvances of the ice may have affected the northern and eastern parts of the region must also be borne in mind.

Possible early drift. The earliest stages of the ice retreat across the area under examination are recorded in the valley of the Little Delaware, where the ice moved southwestward and westward down the valley, and along the upper courses of Neversink and Rondout creeks, where, also, the movement was southwestward down the valleys.

In each of these regions the glacial deposits seem to be notably older than those observed elsewhere. Flood plains are wider; extensive alluvial fans have developed; the forms of the drift seem more subdued; and drift terraces appear to be much more dissected by streams than elsewhere.

These features suggest the possibility that the ice of the latest glacial advance did not reach these localities, sheltered, as they are, in the lee of the higher Catskills.

Ice movements in Esopus and Delaware watersheds. The major valleys on the north side of the Slide mountain range—Big Indian hollow and Woodland valley—appear to have been last occupied by local glaciers moving northward.

The valleys leading southward and southwestward from the central escarpment of the Catskills, which extends northwestward from Plattekill and Overlook mountains to and beyond Stamford,

were all important channels of ice movement, and those which head in gaps in that escarpment all carry heavy deposits of moraine whose southern limits are marked, in a general way, by the Esopus valley and by the valley of Bush kill between Grand Hotel and Arkville. From Stony Clove, Forest Valley and Bushnellsville creek, the ice entered Esopus valley, spreading, in bulb form, both up and down the valley.

Of the valleys at the head of the east branch of the Delaware river, those heading against the central escarpment, namely, those of east branch, Batavia kill, and Vly creek have massive moraines ending respectively at Margaretville (?), Kelly Corners and Griffin Corners, whereas those which do not extend back to the escarpment, notably Red kill, have very little morainic material in them.

There are strong moraines near Stamford and between Stamford and Hobart, opposite the gaps in the escarpment east of Stamford, and there is an almost unbroken series of morainic loops along the valley of the west branch of the Delaware river from South Kortright, 4 miles below Hobart, to Delhi and beyond. These moraines are most strongly developed along the south side of the valley.

At about the time that ice lobes were descending from the Bushnellsville and other valleys into Esopus valley, the great tongue of ice on the Hudson river lowland lay across the mouth of Esopus creek. From it, lobes of ice pushed westward and north-westward into the valleys of Beaver kill and Little Beaver kill, and pushed up the Esopus nearly to Phoenicia, impounding a lake in Esopus valley. Meanwhile the ice lay banked against the eastern spur of the Catskills at High Point, south of the Esopus. At this period, which must have been a long one, the marginal drainage of the ice, together with all the drainage of the Esopus watershed, discharged into Rondout creek through the "Gulf" past Peekamoose lodge, and cut a magnificent gorge. Later, as the level of the ice banked against the eastern spur of High Point was lowered to that of the bottom of the "Gulf" (1677 feet), the latter was abandoned and a sharp notch, "Wagon Wheel gap," noted by Darton¹ was cut in the mountain spur. Further lowering of the ice caused this channel to be abandoned. The lower slopes of the spur have not been examined.

¹ Darton, N. H., Preliminary Report on the Geology of Ulster County, N. Y. State Museum Rep't 47. 1894.

Ice movements in Schoharie valley. North of the central escarpment the ice movements, dominated by the major features of the topography, were very complex. The principal valleys tributary to the upper Schoharie trend approximately across the general direction of the ice movement at the flood stage, and the valleys of the two upper branches of Schoharie creek are entirely open to the east where they have been beheaded by the retreat of the Catskill front.

In the lower Schoharie valley, nearly as far up as Prattsville, the ice movement at all stages appears to have been southward, up the valley. In the valley of the Batavia kill tributary above Red falls, and of Schoharie creek above the mouth of Little West kill, the general ice movement at an early stage of the retreat was westward, down the valleys, as is indicated by moraines and abundant striae in the valley of Batavia kill and by moraines along the north side of the valley of Schoharie creek. This current met the opposing current, moving up Schoharie valley, in the general neighborhood of the junction of Batavia kill with the Schoharie where, by alternating advances of the opposing currents, a complex series of moraines was formed. Between the opposing ice tongues small lakes were impounded, as is shown by a series of hanging deltas.

At a later stage in the retreat, ice from the lobe in the Hudson valley pushed into the open eastern ends of the Schoharie valley past Kaaterskill and Plaat clove to the vicinity of the junction of the two valleys between Tannersville and Hunter, while ice from the north lay banked against the East Jewett range, pushing a tongue into the pass south of East Jewett, another through the gap south of Beaches Corner, and a third and larger one round the western end of the range at Jewett Center. The latter spread out as a bulb in the alley of Schoharie creek and seems to have blocked the valley, impounding a lake in which deltas were built at various levels by the streams carrying outwash from the tongues of ice which pushed through the gaps in the range farther east.

The ice stood in this general position long enough to build conspicuous moraines. Meanwhile, the great, fluted, drumlinlike deposits of thick drift which lie across the valley of East kill, especially between Beaches Corner and the pass south of Hensonville, were probably accumulated beneath the ice.

Small deltas in the valley of East kill, between East Jewett and Beaches Corner, indicate that the ice melted out of this part of the valley while the lower end was still blocked.

At the next later stage of the retreating ice front to be marked by conspicuous moraines, the ice was pushing through the gaps in the northeastern border range between Mount Pisgah and Windham High peak and building massive moraines in the valleys tributary to Batavia kill at and above Windham. The ice from the gap at East Windham bulged eastward into the upper Batavia Kill valley above Hensonville and impounded a lake in which deltas at two levels, approximately those of the cols south of Big Hollow and Hensonville, respectively, were built. At Windham and below, the ice at this stage discharged into the waters of the glacial lake whose outlet was through the central escarpment at Grand gorge.

East and northeast of Windham are about a dozen perfectly formed drumlins whose origin is probably connected with the spreading of the ice after its passage through the narrow gaps in the northeastern border range.

Local glaciation. Special attention was given to the problem of local glaciation, evidences of which had previously been discovered at a few points.

On the north-facing slope of the central escarpment, no less than ten valleys were found in which distinct morainic loops, convex down-valley, testify to the former existence of independent local glaciers moving northward and northeastward in a direction directly opposed to that of the movement of the continental glacier. Many other valleys, similarly situated, contain deposits which, considered individually, do not constitute convincing evidence of local glaciation, but which, taken as a whole in the light of more definite evidence in neighboring valleys, seem to be most reasonably interpreted as the products of local glaciers.

A characteristic type of deposit, found in most of the valleys on the north face of the central escarpment, and elsewhere in similar situations, is a mass of smooth, thick drift which makes a distinct step in the valley bottom with a steep slope up to the top of the step and a more gentle slope above. Such deposits commonly present a convex front down the valley and many of them are higher in the middle of the valley than at the sides. In many instances it is clear that they were fashioned by local glaciers moving down the valleys. Field study led to the hypothesis that they were built, in a manner analogous to the formation of drumlins, by deposition of till beneath the ice where its transporting ability was decreased, either on account of its thinness near the end or on account of its spreading in the form of piedmont bulbs

on being released from the confines of the narrow mountain valleys. Some of the deposits may be moraines of local glaciers overridden by later advances.

In addition to the indications of local glaciation furnished by the short, steep valleys on the north slope of the central escarpment, there is evidence which suggested and gives strong support to the theory that the valleys of Little West kill and West kill, respectively $4\frac{1}{2}$ and 11 miles long, were for a time occupied for their full length by independent local glaciers. Unfortunately the evidence on which the above theory is based can not be adequately presented in the space available for this abstract.

South of Esopus creek, in the valleys on the north side of the Slide mountain group, there were also local glaciers, some of them of large size. Big Indian hollow, at least above Olivera, and possibly for its whole length, was occupied by a local glacier. A smaller one descended the north slope of Balsam mountain, southwest of Big Indian and reached levels at least as low as 1400 feet. Woodland valley, which heads on the north side of Slide mountain, was occupied by a local glacier which left distinct moraines at Woodland and less distinct ones a mile below. Whether the great morainic embankments in Esopus valley at Phoenicia were built by a bulb of a local glacier from Woodlawn valley is a problem whose solution requires further field study.

There is evidence that, for a time at least, local glaciers occupied the Stony Clove valley and its higher tributaries, but whether the great moraines in the lower part of the valley at Chichester belong to the morainic system of a local glacier could not be definitely determined by reconnaissance.

The critical elevation necessary for the formation of local glaciers was found to be about 3400 feet, and the glaciers in the smaller valleys descended to various levels down to 1400 feet. In the larger valleys, heading in the highest mountains, what are believed to have been local glaciers reached levels between 1300 and 1400 feet above the sea at the mouth of West kill and, possibly, of 800 feet at Phoenicia.

A noteworthy feature of the local glaciation of the Catskills is the weak development of land forms produced by glacial sculpture, namely, cirques and trough valleys. The heads of the valleys tributary to the upper West kill and those heading on Hunter and Plateau mountains present evidences of weak cirque action, but typical, strongly sculptured cirques were nowhere recognized.

This condition harmonizes with the evidence of very slight glacial erosion in the bottoms of all but a few of the valleys occupied by glaciers, and with the fact that the moraines of the local glaciers are built largely of drift previously deposited by the continental glacier.

All these features indicate that the local glaciation of the Catskills, though extensive, could not have been of long duration.

The moraines of the local glaciers are remarkably fresh and distinct and are undoubtedly among the most recent glacial deposits of the region. The evidences upon which a statement of the exact date of local glaciation might be based have been partly worked out, but not in sufficient detail to warrant review here.

Broader problems. The work of the past summer, in addition to its contribution to the knowledge of the local details of the glacial history of the Catskills, brought forward two major problems of more than local interest.

The first is based on the seeming greater age of the glacial deposits in the lea of the Catskills than elsewhere, and may be stated as follows: Did the ice of the last glacial epoch (possibly corresponding to the Late Wisconsin of the Middle West), though it pushed into the northern and eastern Catskills, fail to override the southern ranges?

The second is based on the somewhat anomalous phenomenon of extensive, though seemingly short-lived, local glaciation in a region far to the south of such mountain groups as the White mountains, Green mountains and Adirondacks where the evidence hitherto presented indicates a very limited development of local glaciers at the close of the last glacial epoch. The problem may be stated thus: Is the local glaciation of the Catskills a border phenomenon of an ice sheet which ended in the Catskills, or is it merely a phenomenon of the retreat of the continental glacier from its maximum limits in New Jersey and Pennsylvania?

The solution of these two closely related problems should be made the first object of future studies.

INDUSTRIAL GEOLOGY

Mr David H. Newland reports as follows:

Mining summary. The usual summary of the mining developments, with statistics of production, was presented in the form of an annual bulletin for the information and guidance of those interested in the local resources. The year's contribution of crude

ores and of mineral products in first marketable forms was valued at \$35,988,407, a total equal to that of the preceding year, but rather below the normal output. It was an exceptional season, marked by great prosperity in certain branches of industry and by equally great depression in others, such contrasting conditions as have scarcely been witnessed in any previous period. There was a notable revival of activity among the iron ore properties which will probably lead to a new record in the output for the current year, and some expansion in other lines; but the market for building materials (stone, clay and cement) was poor and led to decreases in these important items of local productions.

A new industry came into existence in 1915 with the inauguration of zinc mining in the Edwards district of St Lawrence county. The first ore shipments (several thousand tons for the year) are an earnest of a substantial increment in the State's developed resources. The district has long been known for its valuable talc deposits, but the value of the metallic minerals, which include both pyrite and zinc, has only recently gained recognition.

Quarry materials. An appraisal of the quarry resources that are contained in the crystalline formations, mainly Precambrian, was published during the year as Bulletin 181 of the State Museum. The various kinds of products derived from these formations are granite, gneiss, marble, trap and pegmatite, all of which have considerable commercial importance. Their distribution and local development are presented comprehensively; and some of the more attractive building or monumental stones are reproduced, as faithfully as may be, in color. The description of the local features is preceded by a general discussion of the fundamental geological structures of the State as a key to the distribution of the resources; and by chapters on the qualities, physical and chemical, which determine the value of stone for different uses, and the methods available for their discrimination in the field and laboratory.

Zinc ore investigations. Steps have been taken to meet the call for information, which has come to the department from all directions, in regard to the general features of the zinc ore occurrences in the Edwards district and their probable economic importance. In addition to the areal mapping of the region now in progress, it is purposed to carry out a special investigation of the more limited area in which the ores occur. The necessary field work for this investigation, in fact, has already been practically completed. Short summaries of the developments and geological

conditions in the district have been prepared for the technical and scientific press, preliminary to the complete report which it is hoped will soon be ready for publication.

The Edwards zinc district stands quite apart from the other productive areas of the country, for the deposits are found in Precambrian (Grenville) limestones, about the lowest and oldest of the geological formations that can be definitely recognized with a place in the stratigraphic sequence. So far as known there are no other active mines based on sulphide ores in this association, although occurrences of similar type have been discovered from time to time in the Canadian Grenville areas. The problems connected with the derivation of the ores and the time of their introduction necessarily are complicated by the vicissitudes of age. The wall rocks have been subjected to intrusion repeatedly, have been broken up, strongly compressed and metamorphosed, so that their structure and original characters are most obscure, only to be cleared up by careful study and weighing of the evidences.

Miscellaneous. The demands upon the office for information and guidance in matters pertaining to mining and mineral resources have been particularly large in the last year or two, partly as a result, no doubt, of the unusual commercial and industrial situation generally. Requests of this character are always given consideration, and so far as compatible with the practice of the office the desired information is promptly supplied. In many instances this can be done by the mailing of a published bulletin, for which only a nominal charge is made. It should be noted, however, that the office does not undertake to supply analyses of ores and minerals in competition with public laboratories, although there seems to be a very general impression to the contrary. Samples, however, may be submitted for identification and an opinion as to their value, which can be given in most cases with a close approximation to the truth upon the basis of experience and tests that are readily applied. To carry out an exact analysis is the work of one or more days and can not be undertaken except under special circumstances where the matter is of unusual interest.

PALEONTOLOGY

The Museum. The work of installation in the division of paleontology was actively continued during the year. There were added two cases in the hall of fossil plants, one large wall case in the hall of vertebrates, and three cases in the hall of invertebrates. Of the two new cases of fossil plants, one contains Devonian

plants from western New York and the Catskill region, the other Upper Devonian plants from Scaumenac bay, P. Q., Canada. The new case in the hall of vertebrates is a large wall case devoted to the remarkable Devonian lung fishes and ganoids from Scaumenac bay. A recent Australian lung fish and a recent ganoid from the Nile have been installed for comparison with the fossil forms. The new cases in the invertebrate hall comprise two AA cases of crinoids in the general collection, and an upright case of starfishes and echinoids. The two AA cases of starfishes have been rearranged and much new material, lately described, has been added.

The special exhibit of corals, filling eight AA cases altogether, has been finished.

Mr Henri Marchand has added four more wax models of graptolites to the series in process of construction. This series will illustrate not only the remarkable variety of forms attained by graptolites in the Paleozoic seas of New York, but also the distinct genetic series which they form, from irregular sessile bushes to highly symmetric floating and swimming forms.

An exhibit of the Pleistocene fossils from the marine invasion of the Champlain basin at the end of the last glacial period has been installed in special cases. In obtaining this fine and comprehensive collection the important observation was made that the marine shells decrease in size and thickness as one goes southward from the St Lawrence region, and that at the same time one species after another drops out, until at the southernmost locality of marine Pleistocene shells at Crown Point, N. Y., and Chimney Point, Vt., only small representatives of *Macoma groenlandica* Beck and *Yoldia arctica* Grey are left. From the changes brought about in marine forms where a gradual freshening of the water takes place, as in the Baltic Sea, it is inferred that these facts indicate a gradual decrease in the salinity of the Hochelagan sea southward, until at Crown Point the water had become so fresh that it no longer could support marine forms. The continuation of the Champlain clays proves that the sea itself extended much farther south.

Guidebook. A Guide to the Paleontologic Collections (35 pages) which purports to give a popular account of the fossils shown and of their biological and geologic relationships has been prepared for free distribution to visitors who are sufficiently interested in the collections to inquire for it.

Field work. The field work consisted of the two months' collecting trip in the Pleistocene and about six weeks' investigation of

the Utica, Frankfort and Lorraine formations in central and north-western New York, the funds not allowing a longer stay in the field.

Researches. The field work of the year here recorded, together with a few weeks of research in the field, in the preceding year, have furnished sufficient data to continue the laboratory investigation of the Upper Ordovician shale and sandstone terranes of the Mohawk and Black River valleys; the first instalment of which was published in Museum Bulletin 162, entitled "The Lower Siluric Shales of the Mohawk Valley." In this publication the Trenton age of the black shale (formerly Utica) and sandstones (formerly Frankfort and Lorraine) of the Lower Mohawk valley was demonstrated.

In the westward continuation of this work in the last two years, the Utica, Frankfort and Lorraine beds of the Upper Mohawk and Black River valley were investigated. It was found that the true Utica shale in the Utica basin contains at least three major graptolite zones, to which a fourth or younger zone is added in the Black River valley. This rests on Trenton limestone younger than the Trenton of Trenton Falls. The black shale hence shows a continuous and progressive rise in the time scale from the Hudson river westward and northward to the St Lawrence river, from lowest Trenton to post-Utica age. A distinct graptolite zone develops also in the Black River valley in beds corresponding in stratigraphic position and lithology to the Frankfort shale of the Utica region. Collections of Lorraine fossils from the Lorraine gulf and the deep ravines intersecting the Lorraine plateau toward the Black river at the Whetstone gulf, with careful notation of their horizons, have been made and it is expected that their study will also permit the subdivision of the Lorraine formation on the basis of its faunas and a subsequent correlation with the horizons distinguished in the Ohio basin and in Canada. It is by this careful analysis of the faunas of sections that the facts of the shiftings of the ancient epicontinental seas are established and the basis for paleogeographic maps of the different periods furnished. The work on the Lorraine formation could not be fully completed owing to the lack of funds.

Occurrences of Mastodon and Mammoth

In my report for 1903 a summary was given of the recorded occurrences of the mastodon in this State, and this summary has been supplemented in succeeding reports as new discoveries were announced both of the mastodon and the mammoth (*Elephas*).

Additional lists have been published in the reports for 1906, 1907 and 1909.

Further discoveries and items not before recorded are here given, including several localities where mammoth remains have been found.

Onondaga county

Near Salina. Two specimens of mammoth teeth in possession of the Museum bear the label "Near Salina, N. Y." One specimen is a single nearly complete tooth; its small size and immature appearance stamp it as one of the milk teeth. The second specimen is a fragment of a small tooth.

Near Minoa. Specimens from a mammoth obtained from the east side of Limestone creek near Minoa have been described by Dr Burnett Smith.¹ The remains were unearthed during the construction of the West Shore Railroad about 1883, and consist of one tooth and parts of a tusk or tusks. The best preserved part of the tusk and the molar are in the museum of Syracuse University.

Wayne county

Near Clyde. In November 1910 a mammoth tooth was received from Mr William B. Landreth, deputy state engineer. A letter from Mr B. E. Failing, resident engineer of Lyons, N. Y., gives these details: "The mammoth tooth was found while excavating for lock 26, Barge canal, 2½ miles east of Clyde, N. Y. It was found about 100 feet from the Clyde river and 22 feet underground in a layer of sand and clay, on top of gravel which appears to have been the old river bottom."

Near Savannah. In October 1916 there were dug up in a gravel pit near Savannah, two excellently preserved mammoth teeth consisting of the back upper left and right molars. They were about 8 feet underground and 4 feet apart. These teeth have been purchased by the Museum.

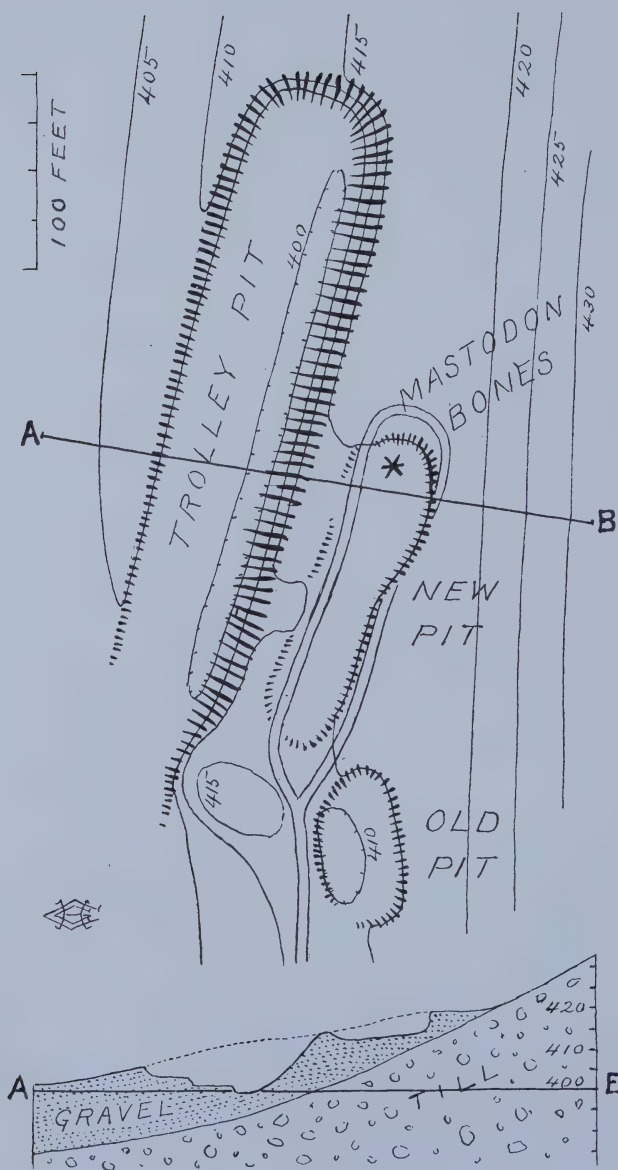
In September of this year an additional find, consisting of the right shoulder blade, was reported. The bone has been presented to the Museum by Mr Gipson Mead of Savannah, N. Y. Recently Prof. G. H. Chadwick has visited the gravel pit and his report is here incorporated.

The Savannah Mammoth. The gravel pit at Savannah from which the two mammoth teeth and the shoulder blade were previously secured was visited on October 27th, at which time exca-

¹ New York State Mus. Bul. 171, p. 68 (1914).

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DETAIL MAP AND SECTION
OF THE MESNER GRAVEL PIT

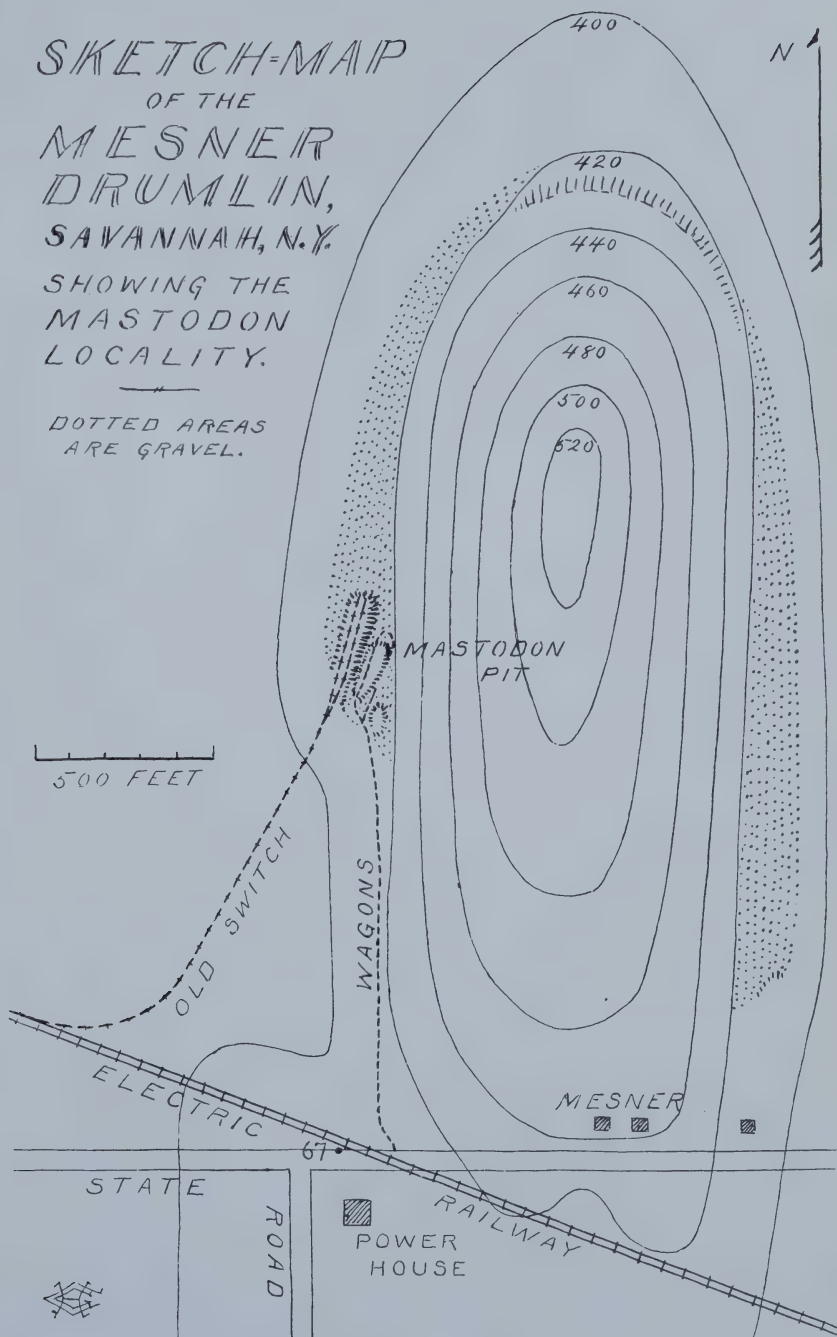
SKETCH-MAP

OF THE

MESNER DRUMLIN, SAVANNAH, N.Y.

SHOWING THE
MASTODON
LOCALITY.

— — — — —
DOTTED AREAS
ARE GRAVEL.



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vation had ceased for the winter. A systematic search resulted in the finding of two more pieces, belonging to the leg and foot, which are transmitted with this report. A sketch map with cross-section of the area is also submitted.

The chief interest of this find is the character of the occurrence. The locality is a gravel pit on the west side of a high drumlin hill one mile due northwest of Savannah, N. Y., at the northwest corner of what Fairchild has aptly called the "*heart* of the drumlin area." The isolated nature of this drumlin mass, surrounded by wide marshes as is strikingly shown by his plate 12 of Bulletin 111 of the Museum, is due to the fact that it was "an island or rather an archipelago in the waters of glacial Lake Iroquois. The gravel pit itself, which is about 1400 feet due north of the power house (stop number 67) on the Rochester, Syracuse & Eastern electric railway, is dug in one of the beach spits built by the waves of the lake, and its summit level of about 420 feet above the sea therefore marks the position of the ancient water surface. This level is over 30 feet above the surrounding marshes, indicating clearly that at no point between this mass and the mainland or the neighboring islands could the icy waters of Lake Iroquois have been less than 30 feet deep. Nor was it anywhere less than one-fourth of a mile across to the nearest other land, which was, like itself, an island.

There is every reason to believe, nevertheless, that the bones were buried in these beach gravels by the waves themselves, and at the time when Lake Iroquois was at its full height. In no other way could they have become so interstratified with the beach shingle. Three pits have been opened here: a large one (90 by 325 feet) on the west slope of the spit by the trolley company during the construction of their line, and two smaller ones (respectively 50 by 170 and 40 by 80 feet) on the crest of the beach for road metal. These upper pits are shallow, not over 6 feet deep, in the finer surface gravels, stopping when they reach the underlying coarse gravels that appear in the railway pit just below them. It is the larger and fresher of these shallow upper pits that has furnished the remains so far found. Besides the portions that have been saved, a crumbling tusk appears to have been shovelled in with the gravel, and there is no knowing how many other small bones or fragments have been distributed upon the roads of the town. The two pieces just collected lay unrecognized among the rejected larger cobbles.

The separation of the parts, especially the isolation of the teeth, and the fact that the pieces found have belonged to various portions

of the animal, harmonize with the belief that they were the play of the waves, yet not carried far. Lying high in the gravel ridge, yet mostly beneath the reach of plant roots, they have escaped rotting, suffering chiefly from pick and shovel. The problem that engages us is, How did the mammoth reach the island?

Without attempting to defend any theory, the following possibilities are suggested: that he swam there; that he crossed on the ice in winter; that mammoths may have roamed on the surface of the glacier itself and been drifted to this shore by icebergs; that the bloated carcass was floated to the island; that a mammoth colony may have been marooned on the Savannah island by the slowly rising waters of Iroquois, since that lake is now known to have been flooded back upon the south shore by slow uplift of its outlet region. These are some of the possibilities that present themselves; it is not imperative that their pros and cons should be argued until more is known about the pit and its fossil contents. The outstanding fact that seems unlikely to be modified by further evidence is that this occurrence fixes the existence of living mammoths in western New York during the closing phase of full-height Iroquois, a lake that coincided with the period of final recession of the second Wisconsin glacier from the Ontario basin and upper St Lawrence valley.

Madison county

Near Canastota. In August of this year Dr. Burnett Smith reported the discovery of mastodon or mammoth bones. The occurrence is 4 miles north of Canastota and 2 miles distant from the south shore of Oneida lake. The bones were found while excavating for a drainage canal in the extensive swampy region lying to the south of Oneida lake. At the present writing, one each of the following bones have been uncovered: femur, ulna, radius, rib, patella.

Chittenango. Among the collections are several ribs bearing the label "Chittenango, N. Y., E. Emmons 1873." From the same collection are two tusks, with the ivory in an excellent state of preservation. They bear the label "Chittenango, N. Y." From the character of the tusks, these remains are referred to the mammoth. (See Tenth Ann. Rep't State Cab. Nat. Hist. 1857. p. 188.)

Orange county

Near Harriman. In October 1913 there was acquired by the gift of Mr W. J. Post of Harriman, N. Y., a finely preserved tusk of the mastodon. The specimen was found about 2 miles south of

Harriman station (Erie Railroad). It was covered by about 6 feet of muck at the bottom of a pond which had become dry at this season.

Near Vails Gate Junction. During the summer of 1917, remains of a mastodon were found on the muck land of Antonio Fisher, one-half of a mile west of Temple Hill monument and 1 mile north of Vails Gate Junction. The find consists of a few scattering bones together with a well-preserved lower jaw containing the four teeth. These remains were found in a shallow excavation 2 feet below the surface. In size the jaw is slightly larger than that of the Cohoes mastodon.

Near Milton. About 1890 a very small tooth of a mastodon was found near Milton by Charles Kniffen, on the farm now owned (1917) by J. R. Bray. The tooth at the present writing is in the possession of the finder.

Schenectady county

South Schenectady. In 1914 a fairly well-preserved tooth of medium size of the mastodon was obtained from the gravels at South Schenectady by Richard Ribley, who still has possession of it.

Cortland county

Near Homer. Among the collections are two mammoth teeth carrying the label "from near Homer, N. Y." One is a complete large specimen, the other has one end broken away. The part remaining represents two-thirds of the specimen.

Niagara county

Lewiston. In 1912 the remains of mammoths were found in a gravel pit of the Iroquois beach, not more than 40 rods from the railroad station at Lewiston. The parts recovered include two atlases, one complete molar, parts of two other molars, the pelvis, a few ribs, and one vertebra. The layers of sand and gravel dip at nearly 45° east or southeast, and the bones were found in several layers aggregating 6 to 10 feet and 20 to 40 feet below the flat top of the terrace.

Warren county

Near Queensbury. Among the collection of local objects from the vicinity of Glens Falls presented to the Museum by James A. Holden is a large tooth of a mammoth. The specimen was found on the farm of John Harris in upper Queensbury.

MINERALOGY

Exchanges. Pursuing the policy that the large stock of duplicates both in the general mineral collection and in the New York State collection should be utilized as a means of acquiring by exchange desirable new material for both collections, a circular letter was issued to a group of private collectors soliciting exchange and stating the needs and standards of both collections. This policy, which will be adhered to in the future developing of this section of the Museum, has already enriched the collections in both exhibited and study specimens. The high standard already set by the exhibited specimens in both collections makes it increasingly difficult to add new material, which, at least in the case of an addition to the general collection, must be subjected to a rigorous comparison with the displayed suite, and which must prove its right to a place in the exhibited series by displacing a corresponding specimen.

Guide. The visitors' guide to the mineral collection which was issued in October 1916, and distributed to the public in response to a request, has met a demand amounting to about 100 copies a month. It fills a gap in the educational scheme of this section of the Museum in that it supplies to the visitor whose interest has been aroused, popular information of a more detailed character than can be gained from the necessarily brief group labels, and it also opens the way for a more comprehensive study of the collections, using Bulletin 58 as a textbook. In line with this idea, a reference table has been placed in the center of the collections, equipped with several of the mineralogic publications of the Museum, descriptive of the collections.

Lectures. The extension work of the section of mineralogy has grown in the past year. In addition to the two lectures delivered in the State Museum course, the curator of mineralogy has been called on to deliver the following lectures and addresses:

"Lettered Signs" before the State Library School.

"The New State Museum and the Peoples University" before the Peoples Forum of Binghamton, N. Y.

"Diamonds" before the Chemical Society of the State College for Teachers, Albany.

"Gems and Gem Minerals" before the Woman's Club of Hudson.

"Gem Symbolism in Legend and Folklore" before the Albany Philosophical Society.

"The Installation and Development of the Mineral Collections of the New York State Museum" before the New York Mineral Club, New York City.

"Methods of Museum Installation as Illustrated in the New York State Museum" before the State Library School.

Research. Crystallographic research has been confined to the study of several occurrences of barite, the material for which was furnished by the general collection, and an occurrence of wernerite, the material for which was drawn from the New York State collection. Both studies have resulted in the establishment of new crystal forms.

VII

REPORT OF THE STATE BOTANIST

Noteworthy contributions. The most important additions to the state herbarium during the past year are contributions of specimens from Prof. J. J. Davis, of Madison, Wis., the New York Botanical Garden and Dr J. R. Weir of Missoula, Mont., in addition to the collections made by members of the staff.

Wild Flowers of New York. The season of 1916 was largely spent in continuation of the field work necessary for the completion of the proposed memoir on the Wild Flowers of New York State. This work was started early in August 1915 and with the appearance of the earliest spring flowers in April 1916, the work was carried forward and completed late in September of the past year. During the two months of 1915 and the six months from April 15 to September 15, 1916, there were photographed in the field 364 species of plants which, because of their conspicuous flowers or attractive appearance, might be classed under the rather indefinite term of "wild flowers."

The 364 illustrations will be in colors and grouped on about 264 plates, of which 161 plates will have each a single illustration and the 103 remaining plates will contain two illustrations each. The text will consist of a brief description of each species together with its range and such other remarks concerning its habitat as seem proper.

By means of a specially constructed apparatus as shown in the accompanying illustration each flower was photographed in position as it grew, without any interference from wind or excessive sunlight. For each subject there were taken one or two (usually two) dry plate photographs and one lumiere (autochrome) photograph. These were usually developed within a few hours so that any serious faults might be corrected by taking another exposure of the subject.

It is proper to remark here that the success of these photographs is largely due to the skill, patience and enthusiasm, often under disagreeable physical circumstances, shown by the two photographers employed: Mr Walter B. Starr of the Matthews-Northrup Company, Buffalo, and Mr Harold H. Snyder of the Zeese-Wilkinson Company, New York.



View of cage used to protect wild flowers from wind while photographing

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Each subject photographed was given a number in order to facilitate its designation in subsequent correspondence, engraving and arrangement in final order. Photographic proofs of the dry plates were marked with directions for size of completed illustration and such other alterations as seemed desirable and duplicate copies of such proofs were kept on file in the Botanist's office. From retouched photographs approved by the Botanist, the engraving companies made their plates for engraving and these were etched down with the autochrome positive as a color guide until each of the four copper plates gave the proper register of color when used upon the press in combination with one another, that is to say, blue, yellow, red and black.

Scientific investigations. A rather limited amount of time was devoted to the completion of a reconnaissance of the vegetation and its ecological relations about the eastern end of Oneida lake, a region of extensive sandy barrens, swamps and bogs in addition to the broad, sandy beach of the lake and the numerous shallow waters of the lake shore and the streams flowing into the lake, the home of numerous water-loving plants. Because of soil conditions and a climate, influenced to some extent by the Great Lakes, the region is characterized by a large number of plants common to the northern coastal plain. The results of this investigation appear in the Botanist's report.

Exchanges. Duplicate specimens of fungi, ferns and flowering plants have been exchanged for desirable material with the New York Botanical Garden, the National Herbarium at Washington, Prof. J. Dearness of London, Canada; Dr J. R. Weir of Missoula, Mont., and other institutions and individuals.

Additions to the herbarium. The number of specimens of New York State species which have been added to the herbarium from current collections of the staff during the past year is 528, from contributions 375, a total of 903 specimens. Of the total number of specimens received, 131 were new to the herbarium and 25 species are described as new to science.

In addition, about 900 specimens of species extralimital to New York, from the Sheldon herbarium, presented in 1914, representing characteristic species of the eastern and southern flora, have been remounted and incorporated into the herbarium. It is not the aim of the state herbarium to represent to any great extent the flora of regions beyond the State's border. The Sheldon herbarium, however, contains over 13,000 specimens, representing nearly

8000 species, most of them extralimital to New York, and it seems advisable gradually to incorporate the best of them into the herbarium for purposes of comparison with our native species and as an aid in the identification of material collected outside the State by persons who bring or send them here for determination.

Twenty persons have contributed specimens to the herbarium, and the number of species represented by their contributions is 375. This includes specimens sent or brought for identification which were desirable additions to the herbarium.

Collections have been made by the staff in the following counties: Albany, Bronx, Cayuga, Columbia, Genesee, Herkimer, Madison, Monroe, Nassau, Oneida, Onondaga, Ontario, Oswego, Queens, Rensselaer, Suffolk and Wayne.

Identifications. The number of identifications made of specimens sent or brought to the office by 95 inquirers is 465.

Mushroom models. The Peck testimonial collection of models cast in wax of edible and poisonous mushrooms now includes 56 groups of which 8 represent poisonous species. This constitutes a most interesting exhibit and one of high educational value. It is planned to arrange these in an attractive manner in wall cases.

Many of these groups have been the subject of special study and illustration by Doctor Peck. The following list of the groups is collated with reference to illustrations of them which have appeared in publications of the State Museum.

- 1 *Craterellus clavatus* (Pers.) Fr.
Memoir 4, pl. 56, fig. 17-21; 49th Rep't, pl. 44, fig. 1-5 (as *Craterellus cantharellus*)
- 2 *Mitrula irregularis* Peck (*M. vitellina* Sacc. var. *irregularis* Peck)
48th Rep't, pl. 5, fig. 8-14
- 3 *Russula cyanoxantha* (Schaeff.) Fr.
- 4 *Lepiota naucina* Fr. (*Lepiota naucinioides* Peck)
48th Rep't, pl. 19
- 5 *Agaricus arvensis* Schaeff.
48th Rep't, pl. 8
- 6 *Leottia lubrica* (Scop.) Fr.
- 7 *Peziza badia* Fr.
- 8 *Pleurotus sapidus* Kalchbr.
- 9 *Tricholoma personatum* Fr.
48th Rep't, pl. 20
- 10 *Clavaria pistilaris umbonata* Peck
Memoir 4, pl. 66, fig. 15-17

- 11 *Russula roseipes* (*Secr.*) *Bres.*
51st Rep't, pl. 53, fig. 1-7; Memoir 4, pl. 54, fig. 2-7
- 12 *Russula emetica* *Fr.*
- 13 *Lycoperdon pyriforme* *Schaeff.*
- 14 *Peziza aurantia* *Pers.*
- 15 *Tremellodon gelatinosum* (*Scop.*) *Pres.*
- 16 *Clavaria cristata* *Pres.*
48th Rep't, pl. 39, fig. 8-12
- 17 *Cantharellus cibarius* *Fr.*
- 18 *Lepiota procera* (*Scop.*) *S. F. Gray*
48th Rep't, pl. 18
- 19 *Hypholoma perplexum* *Peck*
48th Rep't, pl. 47, fig. 11-18; Memoir 4, pl. 60, fig. 10-17
- 20 *Armillaria mellea* (*Vahl*) *Quel.*
48th Rep't, pl. 20
- 21 *Scleroderma vulgare* *Hornem.*
- 22 *Boletus cyanescens* *Bull.*
- 23 *Tricholoma sejunctum* (*Sow.*) *Quel.*
- 24 *Craterellus cantharellus* (*Schw.*) *Fr.*
- 25 *Russula albidula* *Peck*
- 26 *Pleurotus serotinus* (*Schrad.*) *Fr.*
- 27 *Fistulina hepatica* *Fr.*
48th Rep't, pl. 37, fig. 8-12
- 28 *Geoglossum ophioglossoides* (*L.*) *Sacc.*
- 29 *Hypomyces lactifluorum* (*Schw.*) *Fr.*
Mus. Bul. 105, pl. 103
- 30 *Hydnum albidum* *Peck*
Memoir 4, pl. 67, fig. 1-6; 51st Rep't, pl. 56, fig. 1-7
- 31 *Hygrophorus eburneus* (*Bull.*) *Fr.*
- 32 *Collybia radicata* *Relh.*
- 33 *Chanterel floccosus* *Schw.*
Memoir 4, pl. 55, fig. 9-13; 52d Rep't, pl. 60, fig. 10-14
- 34 *Coprinus comatus* *Fr.*
48th Rep't, pl. 10
- 35 *Boletus alboater* *Schw.* (*B. nigrellus* *Peck*)
- 36 *Clavaria ligula* *Fr.*
- 37 *Russula virescens* *Fr.*
48th Rep't, pl. 31
- 38 *Calvatia elata* *Massee*
- 39 *Gyromitra brevipes* *Fr.* (*G. esculenta* very similar to this is
illustrated in 48th Rep't, pl. 5, fig. 1-3)
- 40 *Gyromitra brunnea* *Underw.*
- 41 *Sparassis crispa* (*Wulf.*) *Fr.*

- 42 *Morchella deliciosa* *Fr.*
48th Rep't, pl. 3, fig. 4-7
- 43 *Strobilomyces strobilaceus* (*Scop.*) *Berk.*
Mus. Bul. 94, pl. 92
- 44 *Craterellus cornucopioides* (*L.*) *Pers.*
48th Rep't, pl. 24, fig. 7-10
- 45 *Polyporus sulphureus* *Fr.*
48th Rep't, pl. 37, fig. 1-4
- 46 *Polyporus caudicinus* (*Scop.*) *Murr.* (*P. squamosus* *Huds.*)
- 47 *Agaricus campestris* (*L.*) *Fr.*
48th Rep't, pl. 6, fig. 1-10
- 48 *Amanita caesarea* (*Scop.*) *Pers.*
48th Rep't, pl. 10
- 49 *Tremella lutescens* *Pers.*
- 50 *Clitocybe illudens* (*Schw.*) *Fr.*
Memoir 4, pl. 68
- 51 *Hypomyces hyalinus* (*Schw.*) *Tul.*
- 52 *Amanita phalloides* *Fr.*
(Four models showing variations in color and form)

VIII

REPORT OF THE STATE ENTOMOLOGIST

The Entomologist reports that the frequent and rather heavy rains of the spring and early summer offset, in large measure, depredations by various leaf feeders by producing an unusual growth of vegetation. Apple tent caterpillars were numerous in many localities and yet the damage was relatively small. There were no complaints of injuries by the forest tent caterpillar and very little serious damage by the elm leaf beetle, a pest which, in earlier years, defoliated thousands of trees, and one which has killed many magnificent elms in the Hudson valley.

The subjects briefly outlined in this report are more fully discussed in the annual report of the Entomologist.

Fruit tree insects. Practical work with the *codling moth* was continued the past season in cooperation with the bureau of horticulture of the State Department of Agriculture, and the Monroe County Farm Bureau. These studies were conducted in four commercial orchards in western New York through the hearty cooperation of their respective owners and an effort made to determine the relative value, as in former years, of the first, second and third sprays for the control of this pest. In connection with these investigations, observations were also made upon the development and biology of the codling moth. The data secured show, as do those of earlier years, the very great benefits which may be derived from the first or so-called calyx spray, and indicate most strongly the necessity of thoroughness if satisfactory results are to be obtained. This alone is of great value to the commercial fruit grower, since it indicates the most promising method of controlling a destructive insect. The work in the orchard of Mr H. E. Wellman, Kendall, when compared with that of the preceding year, shows a very gratifying reduction in infestation. The same plots were used and the wormy apples of the past season were from one-third to two-thirds less than those of 1915.

A careful study of the different types of codling moth injury has enabled the Entomologist to verify his earlier opinions as to the relation existing between them and the habits of the insect, and also to outline rules for determining the period during which different types of injury may be inflicted. The latter is of con-

siderable importance in connection with the enforcement of the apple grading and packing law. He has also, through the cooperation of several local observers, secured detailed records of evening temperatures and other meteorological data under actual orchard conditions. Unfortunately the egg laying of the moth was so distributed the past season that it was impossible to demonstrate a well-marked relation between variations in evening temperatures and the deposition of eggs, though it is very probable that such exists. The meteorological data recorded constitute a substantial basis for subsequent investigations. Spraying for the control of the codling moth was followed by serious and somewhat general injury to Baldwin foliage, in particular, due probably to the application of a rather strong fungicide immediately after a series of rains which produced an unusually tender growth.

Continued injuries by the *apple maggot* resulted in beginning an investigation of the pest, with especial reference to practical control measures. This was started through the cooperation of Mr Edward Van Alstyne of Kinderhook, and Mr George T. Powell of Ghent. The results of a series of tests with sweetened poisons for the destruction of the flies were so equivocal that this office is unable to recommend this spray and for the present is content with advising the early destruction of infested fruit, supplemented by good orchard practice. The investigations of the past season demonstrated such variations in the habits of the flies in nearby orchards that a continuance of the study is planned for another year.

Incidental to work with the codling moth noticed above, investigations showed that the *leaf roller*, a serious pest of the fruit grower in the western part of the State, was much less abundant than was the case in 1915. This condition is probably due to one of the natural and frequently unexplainable oscillations in insect life.

Studies of *red bugs* the past year indicate that the two species generally grouped under this common name, are becoming well established in the fruit-growing sections of the State and here and there are causing serious injury. The practical work of the past two years has demonstrated nothing to be more effective than the use of a tobacco extract, 40 per cent nicotine, just before the blossoms open. This may be applied in water to which any cheap soap has been added to aid in spreading the insecticide, or incorporated in the delayed dormant spray. In the case of bad infesta-

tions this last treatment should be supplemented by the use of tobacco in the usual calyx spray for the codling moth and the compound applied as soon as possible after the dropping of the blossoms.

The *San José scale*, greatly feared in earlier years, has caused comparatively little injury in the Hudson valley, and in some sections has been remarkable for its scarcity. This reduction in abundance is probably attributable in large measure to the activities of various small parasites, though climatic conditions may have considerable influence. Unsprayed orchards, even though they have been infested with the scale for a series of years, are in somewhat better condition, generally speaking, than they were eight or ten years ago and a few fruit growers have been encouraged by this comparative scarcity of the pest, to omit the early spring application for the control of the scale. No serious consequences have followed this procedure to our knowledge, though it is a practice which can not be recommended at the present time.

The minute and destructive *pear thrips* have been abundant here and there in the Hudson valley and has caused serious injury in a few localities. Through a combination of fortunate conditions the Entomologist was able to secure a somewhat satisfactory test of the value of a thick lime-sulphur wash as a means of controlling the thrips, the application being made before the buds crack. The results are most encouraging though owing to the erratic habits of the insect, there can be only a qualified recommendation.

Injuries by the *pear psylla* have not been serious, as a rule, in Hudson valley orchards and in many, comparatively few eggs were deposited in early spring. The late application of the winter lime-sulphur wash for the destruction of the eggs continues to be one of the most satisfactory methods of controlling this pest though occasionally the treatment must be supplemented by mid-summer spraying with a contact insecticide.

Gipsy moth. The area infested by the gipsy moth at Mount Kisco was examined, and though the scouting of the winter of 1915 and 1916 revealed an extension of the infested area there was no marked change in the situation. The infested woodland had been well cleaned during the winter and early spring, was thoroughly sprayed in early summer, and in August no living insects were to be found. There is no reason why this local infestation should not be eradicated if the work is prosecuted with desirable

thoroughness and those most conversant with the situation can not gainsay the wisdom of such procedure.

Grass and grain pests. The grasshopper devastations of the last two years on the borders of the Adirondacks were much reduced during the past season, though many young insects hatched in early spring, as shown by observations in Lewis, Saratoga and Albany counties. There were two causes for this change. The frequent and copious rains of the spring and summer produced an abundant forage capable of supporting many grasshoppers without marked injury. The rains doubtless killed many of the young insects by producing conditions unfavorable for their development and, in addition, the systematic poisoning of earlier years over large areas resulted in a great decrease in the pests. The experience of the last three years has amply demonstrated, generally speaking, the practicability of local control through the distribution of poisoned baits.

The *white grub* outbreak of 1915 was followed, as was to be expected, by numerous full-grown grubs in many fields last spring and as a consequence many farmers were afraid to plant susceptible crops on such land. Moderately late planting of these areas was advised and the outcome in the field fully justified the recommendation. General notices were also issued calling attention to the more salient features in the life history of these destructive insects and pointing out the most practical means of avoiding injury. Studies were continued of the white grub robber fly, a species which has proved an important natural enemy of white grubs.

Incidental observations during recent years, upon several minor *clover insects*, have been brought together and placed on record in the Entomologist's report. It will be seen by referring to these two accounts that two European weevils in addition to the much better known and earlier introduced, punctured clover leaf weevil, have become established in recent years in the Hudson valley and in certain localities, at least, are causing an appreciable amount of injury.

Shade tree insects. There has been comparatively little damage to the shade trees of the State, owing in part to the climatic conditions being unusually favorable for the growth of vegetation.

An interesting injury, that of the maple leaf stem borer, has been studied. This insect is a comparatively unknown one in New

York State and occasionally, as shown by observations in other portions of the country, becomes somewhat abundant and injurious.

There is annually more or less bleeding from wounded trees. The past season was characterized by an unusual prevalence of this trouble. While there may be other causes for this phenomenon, observations of the last few years have enabled us to associate much of this damage with slender, white maggots, the young of a small and hitherto almost unknown fly.

Forest tree pests. Injuries by the hickory bark beetle, as shown by observations, have continued though the damage the past season appears to be materially less and, in certain cases at least, seems to be favored by a weakened condition following the severe drought of earlier years. Studies of this species have resulted in securing valuable information respecting the biology and habits of several associated species.

Greenhouse pests. A number of greenhouse insects were brought to the notice of the office during the past year and investigated so far as opportunities permitted. The Florida fern caterpillar, a well-known southern insect, was found well established in a fern house at Lockport.

The rose bud midge, a dangerous enemy of indoor roses, has again appeared in greenhouses in the lower Hudson valley, while reports from different localities indicate a wide dissemination for the recently introduced chrysanthemum gall midge, a species liable to appear in numbers and cause serious injury in almost any chrysanthemum house of the State.

Periodical Cicada. A brood of this remarkable insect appeared in the western part of the State, and detailed records concerning its distribution and abundance, together with observations upon its habits, have been collated and are given in the Entomologist's report.

Flies. There is continued interest in the control of the house fly and a number of requests for information in regard to this insect have been complied with. Mobilization of troops the past summer made it necessary to control flies under camp conditions and at the request of Dr H. L. Van Winkle, the Entomologist made a personal examination of Camp Whitman, Greenhaven, and submitted a series of recommendations for the control of the house fly.

Infantile paralysis. A serious outbreak of this disease made it very desirable to investigate thoroughly the possibilities of flies

or other insects acting as carriers of this infection, and at the invitation of Dr Haven Emerson, commissioner of health, New York City, the Entomologist attended a conference for the purpose of outlining a fly survey. This work was placed in charge of an entomologist employed by the department of health of the city of New York, and the details of the investigation will be made public later.

Gall midges. An unusual number of economic and comparatively unknown species belonging to this group have been brought to our attention during the past year, and the probabilities are that there will be more rather than less injury of this character in the future. The studies of these interesting forms have been continued and a number of new species, mostly reared, and several new genera described.

Key to insect galls. The studies of gall midges have resulted in many insect galls being submitted for identification and, as a matter of convenience, an illustrated key of these deformations has been prepared. This tabulates about 1400 galls in relation to their food plants, gives the principal characters of each deformity and a reference to the best or more accessible description. The key has greatly facilitated the naming of galls and it is believed that its publication will materially increase the interest in this branch of natural history.

Lectures. The Entomologist has delivered a number of lectures on insects, mostly economic species, before various agricultural and horticultural gatherings, some of them being in cooperation with the Bureau of Farmers' Institutes or the county farm bureau agents. Several lectures have also been given under the auspices of local welfare associations.

Publications. A number of brief, popular accounts regarding such common pests as the apple tent caterpillar, pear thrips, white grubs and grasshoppers have been prepared and widely circulated through the press. The Entomologist's report contains a list of his more important publications during the year.

The increased interest in agriculture and nature study resulted in a large demand from school teachers for information relating to insects, and as a consequence the editions of certain more popular bulletins and reprints, some dating back a number of years, were exhausted the past summer. These publications could hardly have been placed to better advantage.

Faunal studies. Investigations along these lines have been continued and a manuscript list of the insects of the Adirondack region, based mostly upon material in the state collection, is nearly ready for publication. This list is a growing one, additions being constantly made thereto in connection with other work carried on within the limits of our faunal area, such as the study of grasshoppers the last two or three years.

Another valuable addition to the natural history of the State is practically ready for the printer, namely "A Monographic Account of the Caddis Flies or Trichoptera," by Dr Cornelius Betten. This work had its inception in the studies of aquatic insects begun at the entomological field station, Saranac Inn, in 1901, many of the results of which appear in Museum Bulletins 47, 68, 86 and 124. The Trichoptera are an important group economically, since there are numerous species occurring in all kinds of fresh waters throughout the State, some of them being exceedingly abundant and consequently of great value as food for fish and other aquatic life.

Substantial progress on the "Monograph of the Stone Flies or Plecoptera" has been made by Prof. James G. Needham. This is another study begun at the entomological field station mentioned above and will make an extensive and valuable addition to our knowledge of an important and comparatively unknown group of aquatic insects. These studies and those already published on aquatic forms, comprise by far the most important additions to our knowledge of American aquatic insects.

The contributions to the natural history of the State from the office of the State Entomologist are worthy of mention in this connection. The scope of these studies, as indicated by the titles cited and the amount of work involved, is suggested by the approximately 3500 pages of text with numerous illustrations devoted to the discussion of the various groups. The more important titles, aside from the long series of reports and bulletins, treating of especially destructive forms, are listed below.

Entomological Contributions 1-4, by J. A. Lintner, appearing in the 23d, 24th, 26th and 30th Museum Reports, respectively, contain many and valuable additions to the knowledge of our local fauna.

Scale Insects of Importance and List of the Species in New York State, by the Entomologist, Museum Bulletin 46. The more

destructive species are faithfully illustrated in color, discussed in some detail and a list given of all the species then known to occur in the State.

Aquatic Insects in the Adirondacks, by J. G. Needham and Cornelius Betten, Museum Bulletin 47. Contains comprehensive accounts of many aquatic forms and is illustrated by a number of admirably executed colored plates.

Monograph on the Genus Saperda, by the Entomologist and L. H. Joutel, Museum Bulletin 74. An extended economic and systematic discussion of these important beetles illustrated by an unequalled series of colored plates.

Mosquitoes or Culicidae of New York State, by the Entomologist, Museum Bulletin 79. The first comprehensive account of New York forms, based upon an exact study of both adult and immature stages, illustrated by a large series of original plates.

Aquatic Insects in New York State, by J. G. Needham, A. D. MacGillivray, O. A. Johannsen and K. C. Davis, Museum Bulletin 68. Contains accounts of numerous aquatic forms with monographic discussions of several groups.

May Flies and Midges of New York State, by J. G. Needham, J. K. Morton and O. A. Johannsen, Museum Bulletin 86. The greater part of this work deals with the Ephemeridae and Chironomidae and there is, in addition, a valuable paper on the Hydroptilidae.

Studies in Culicidae; Jassidae of New York; List of Hemiptera Taken in the Adirondack Mountains, by the Entomologist, Herbert Osborn and E. P. Van Duzee, respectively, Museum Bulletin 79. The three papers specifically mentioned comprise valuable additions to our knowledge, the first being mostly morphological and taxonomic and the others faunal and biological.

Catalogue of the "Phytoptid" Galls of North America; Report of the Entomological Field Station, Old Forge, 1905; New North American Chironomidae; Studies in Cecidomyiidae II, by G. H. Chadwick, J. G. Needham, O. A. Johannsen and the Entomologist, respectively, Museum Bulletin 124. This comprises a series of extensive and important additions to our knowledge of the natural history of the State.

Catalogue of the Described Scolytidae of America North of Mexico, by J. M. Swaine, Museum Bulletin 134. The only comprehensive bibliographic catalog of this group which has appeared.

A Study of Gall Midges, Parts 1-4, by the Entomologist, in

Museum Bulletins 165, 175, 180 and 186. Portions of a monographic account of a large and important family, the American forms of which, prior to these studies, were practically unknown.

Insects Affecting Park and Woodland Trees, by the Entomologist, Museum Memoir 8. Contains many New York records relating to forest and shade tree insects and is the only comprehensive and moderately recent work dealing with this very important group.

Collections. The insect collections of the State Museum, more than those of any other institution of the State of New York, should contain an adequate representation of our rich and economically important fauna. There are probably 20,000 different species of insects in the State, each represented by at least four stages and these, with varieties, specimens of their work and other desirable illustrative material, would mean a collection of some 100,000 different specimens in order to represent properly this great and fascinating complex. The development of this one feature is an enormous undertaking and one utterly beyond the limited time which can be devoted to such work under present conditions.

The assembling and preparation of the enlarged exhibit of insects extended well into 1916 and, owing to the great amount of time required, necessarily prevented very desirable work in the arrangement and classification of the reference collections. Additions to these are constantly being made, especially of specimens representing the early stages and work of various injurious forms, since biological material of this character greatly facilitates identification of the different insects and is indispensable in a well-prepared exhibit illustrating the life histories of different species. Several special collecting trips in connection with grasshopper or other investigations were made by Mr D. B. Young and resulted in securing a considerable number of very desirable specimens. The identification of this material, especially of the crane flies or Tipulidae, has been taken advantage of to rearrange this interesting and hitherto largely neglected family. The state collections now contain a large amount of material which is invaluable because of the associated data. Numerous microscopic preparations of smaller insects have been made and incorporated in the collections as in earlier years.

A number of very desirable additions have been made by exchange, notably those from Mr Paul B. Sears, Columbus, Ohio, Mr W. J. Chamberlin, Corvallis, Ore., and Mr J. R. Malloch,

Urbana, Ill. The species acquired are listed with the other accessions.

The wooden boxes containing the insect collections should be replaced by steel cabinets, as soon as practicable and more provided to accommodate the extra boxes and trays required by the normal increase in the collection. No adequate provision has as yet been made for the constantly increasing biological material and the large number of microscopic slides, many of which contain types of species and genera and are therefore unique. A metal filing case for the collection of negatives and photographs illustrating insects or other work is also greatly needed.

Nursery inspection. Nursery inspection work of the State Department of Agriculture has resulted in a number of specimens representing various stages of insect development, some in very poor condition, being submitted for identification. As such material may originate in a foreign country, determinations of this character are laborious and require for their successful prosecution a large collection and an excellent library of both domestic and foreign works. The correct identification of such material is important, since the disposal of an entire shipment of nursery stock must depend in considerable measure upon the character of the infestation.

General. The work of the entomological division has been materially aided, as in past years, by the identification of a number of species through the courtesy of Dr L. O. Howard, chief of the bureau of entomology, United States Department of Agriculture, and his associates. There has been, as already stated, very effective cooperation with the State Department of Agriculture, several county farm bureaus and other public welfare agencies in the State. A number of correspondents have donated valuable specimens and many have rendered efficient service by transmitting local data respecting various insects. There has been, as in the past, a most helpful cooperation on the part of all interested in the entomological work of the Museum.

IX

REPORT OF THE ZOOLOGIST

In February of the past year, the Zoologist, Dr. Willard G. Van Name, tendered his resignation and left the service of the department. Just preceding his departure, Doctor Van Name was engaged in arranging for exhibit the collections of bivalve mollusks and birds' eggs and relabeling in part the bird collection.

During the period following Doctor Van Name's resignation and the appointment of a new zoologist, a considerable amount of material was worked over and prepared for display by Mr N. T. Clarke and the taxidermist. At this time the collection of corals was unpacked, cleaned and installed in zoology hall; the birds' eggs rearranged and augmented by additional specimens from the recently acquired Conway collection and a series of skeletons of birds, fishes and mammals installed in cases reserved for them. An interesting tree-toad exhibit designed to show protective coloration was placed in zoology hall for the first time and additional specimens of mounted fishes added to those already displayed.

The preparation of groups has proceeded as far as available material would permit. New groups recently installed are a family of woodchucks and a section of a sand bank with nesting bank swallows. The Museum's collection of univalve mollusks, native to New York State, are now on exhibit but many species are needed to complete the series. The accessions to the department during the fiscal year include the collection of birds' eggs and nests of the late Martin J. Conway of Troy and represent about three hundred species. Fourteen pairs of domestic pigeons of as many varieties were secured from Mr B. M. Hartly of West Haven, Conn., and these with the specimens already in the possession of the Museum represent most of the common varieties.

By exchange with the Victoria Memorial Museum of Ottawa, Canada, a number of sea fowl were secured typical of the great nesting community of Bonaventure island.

But little time was available for field work, nevertheless in the few days' collecting a rather extensive series of spiders was taken, including many species new to the State and several new to science.

The visible evidences of the activities of the department repre-

sent but a fraction of the work accomplished during the year. A considerable amount of cataloging and labeling of specimens, with complete sorting and arrangement of the collections of birds' skins and eggs, has been finished.

That there is a growing interest in general natural history and zoology is daily evidenced by the increasing number of inquiries relative to these subjects and the number of visitors to the office of the Zoologist.

X

REPORT OF THE ARCHEOLOGIST

The activities of the Archeologist of the State Museum are divided in the field of research into two distinct groups, each of which requires different methods of approach and study. The field of archeology requires a knowledge of the prehistoric and more recent aboriginal occupation of the State, a knowledge of the various culture areas and the ability to seek out the important centers and excavate them. The field of ethnology requires the study of the folk ways, social organization rituals, folk lore, technology and material culture of the Indians who still survive and who are able to give information concerning their ancestors. It will be seen that the special training needful for equipment in each of these lines of research differs, and that while the two fields are correlated, any attempt to follow both thoroughly requires constant application.

Supplementing the research activities are those of the curator. The archeological and ethnological collections in our custody are extensive and very valuable. To arrange, catalog, label and instal the specimens properly is a work of years and will require careful study. The value of our collections to students of ethnology is such that every effort is being put forth to bring out fully the facts represented by them.

Condition of the collections. The collections placed in the care of this section of the Museum are installed in the mezzanine halls of the top floor and extend from one end of the building to the other. The ethnological collection occupies the most space. Owing to the rarity of the specimens and the relatively small number to be obtained it is not likely that our cases will soon be over-taxed. The installation is in tall cases, centrally placed, and in wall cases having desk extensions. The wampum belts of the Iroquois Confederacy, placed permanently in our custody, are displayed in the ethnological hall.

Care is taken to poison properly all specimens that might become infected with moths or other vermin but we have not yet been able to destroy all vestiges of such life in some of the more recently acquired specimens of food plants. Constant inspection during the year has contributed to the safety of the valuable specimens and

we are now reasonably sure that none of the fabrics are infested with destructive insects. We are still troubled by the entrance of dust into the cases caused by the minute particles of cement dislodged from the floor. There can be no adequate remedy until means are at hand to coat the cement properly with a preparation that will prevent the formation of dust through abrasion.

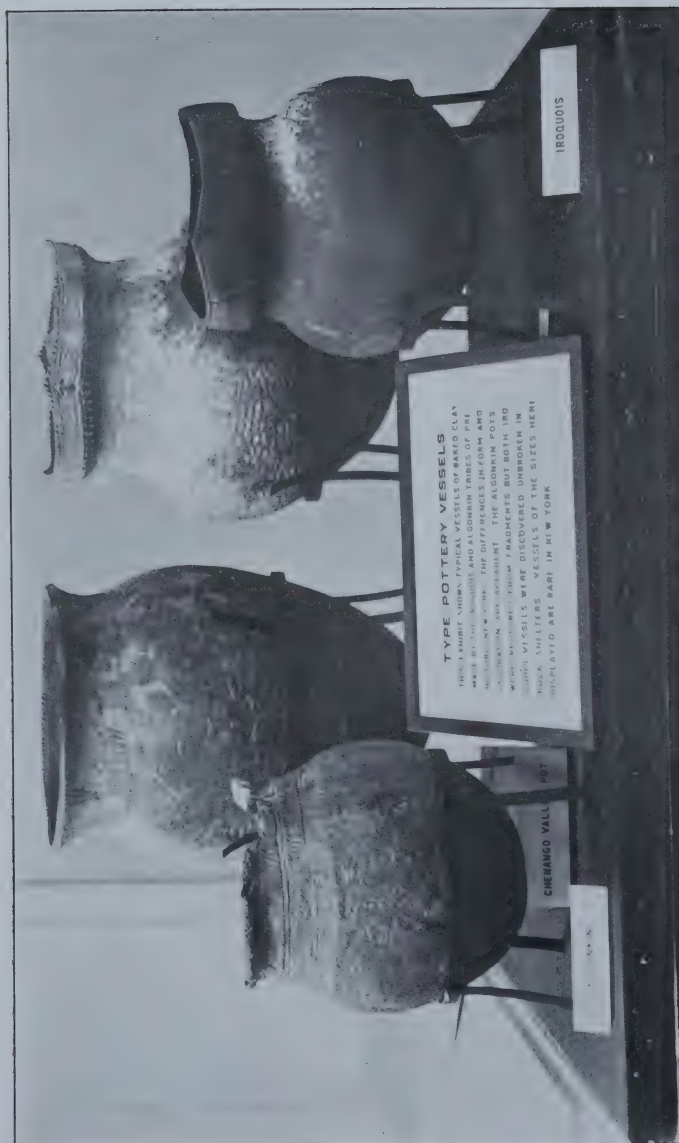
The Iroquois habitat and culture-history groups in the Governor Myron H. Clark Hall of Iroquois Ethnology are constantly receiving attention and care. This is necessary not only on account of the value of the groups, but owing to the necessity of inspecting the electric wiring, protecting the contents from destruction by moths and keeping the accessories in a state of good preservation. During the year all six have been poisoned with a cyanide gas and all fur garments sprayed with mercury bichloride.

The physical condition of the groups is good and no signs of deterioration have become visible since their installation. An effort is made to preserve the proper humidity and to keep the temperature at the uniform degree of 72. Screened ventilators permit the exit of air heated by the electric lamps to a point above normal. There is thus a constantly automatic breathing by the cases.

The detached rooms on each end of this mezzanine are at present serving for other purposes than ethnological exhibits, but only temporarily so. The westmost room, near Swan street, is employed as a convenient lecture hall for museum lectures. The room at the opposite end, at the center of the building, is designed to contain a bark lodge, to be furnished completely with Iroquois utensils. At present the room contains an exhibit of plows, illustrating the evolution of the plow and the plowshare in America.

The hall of archeology is in the eastmost mezzanine. The cases are crowded and there appears to be no room for expansion. The most recent section of the Museum has completely outgrown the quarters assigned to it, and this within the period during which the collections have been installed in the Education Building. Only by carefully selecting the specimens and by restricting the exhibits is it possible to display what we have. There remains but little room for the exhibition of the many relief maps, models and restorations that were originally contemplated. The only relief will be to disjoint and disassociate the collections and remove a section to the west end of the building and eliminate the lecture room.

The archeological collections on exhibition are receiving con-



A COMPARISON OF THE IROQUOIAN AND ALGONKIAN POTTERY VESSELS

This is one of the comparative exhibits outlining the differences between the several cultural types

UNIVERSITY OF CALIFORNIA LIBRARY





THE OWASCO LAKE POT

An Algonkian pot discovered in fragments in an Algonkian site at Lakeside park, near Auburn

UNIVERSITY OF ALABAMA LIBRARY



stant curatorial oversight, each specimen having been selected by the Archeologist and given its place in the exhibition series. The painstaking labors of Mr Howard A. Lansing in cataloging and preparing labels have contributed much to the preservation of the facts associated with the specimens, but the work yet to be done remains enormous.

Our complete plan calls for a typewritten or printed guide book on each case, whereby the student may have a proper understanding of the meaning of each exhibit.

Office work. The work in the office, besides the labor of preparing the catalog and making the proper entries on the records, consists of answering numerous requests for information, for names of Indian localities, and for publications. It is the study and classification of specimens, however, that consumes the greater portion of the time. About ten thousand objects have been placed on exhibition but nearly ninety thousand are stored in drawers for study purposes. These have received attention during the year. Our researches have covered the subjects of industry, experiments in primitive methods of manufacture and experiments to determine the uses of certain forms of "problematical" objects. These latter include banner stones, boat stones, gorgets and bird stones. On these specimens we have made extended notes.

Public interest. The interest of the public, and particularly of the special student, grows from year to year, as is evidenced by the number of letters received, by the personal visits of collectors, historians, museum curators from other states and from foreign lands, and especially by the visits of teachers and pupils in the public schools. Our section is becoming known, as it should be, as a repository of Indian lore of widely varied subjects. Our facilities make possible the answering of appeals for service from the several state departments and in several instances from the federal government. The interest and cooperation of the surviving Iroquois Indians must also be mentioned, and our records are frequently used as a source of information by them. An unusual example is the appeal of the "last remnants of the Mohicans" for assistance in locating Indians in New York State related by blood to them. This was in order to distribute certain funds that the tribe, now living in Wisconsin, had recovered.

Utility of the archeology section. Beyond the scientific and historical value of this section and its value in the study and preservation of New York's prehistory, it has a distinctly utilitarian

value which is appreciated by certain specialists. Our collections are visual illustrations of primitive technology and illustrate the beginnings of industry. We are able to show how early man responded to his environment and what he devised to overcome its obstacles. There is a pointed lesson here that the student of the simpler life appreciates, for we are able to teach by means of the collections, how to employ the simplest things at hand for useful purposes. Modern man is forgetting this and relying on complex devices that he is unable easily to produce without machinery. By means of our exhibits of primitive industries, primitive amusements, primitive agriculture and primitive ceremonials, we respond to vital human interests. We believe that this is a correct museum theory and that one of our highest functions is to meet human needs, physical as well as intellectual.

By this effort to interpret human cultural development we have attracted students of history, artists, writers and advocates of outdoor life. Our exhibitions thus become a source of material of no uncertain value to the public.

Publications. During the year the Museum has published a bulletin on the *Constitution of the Five Nations*, or the Great Binding Law of the Iroquois. This work has been widely sought by ethnologists and by students of primitive civics and law. Copies have been requested by persons in many parts of the civilized world. The edition has all but become exhausted.

Another manuscript is in the course of preparation and deals with the "Archeological History of New York." Additions to the manuscript have constantly been made during the year and it is hoped that it may go to press during 1917. The range of topics considered by this work is a discussion and description of the various culture areas, a list of sites, a series of detailed maps and a description of the earth works, mounds and other evidences of aboriginal work, together with descriptions of implements and ornaments used by the aborigines of the State and the territory adjacent to it.

The New York State Archeological Association. During the year a new statewide organization has been formed by collectors and students of New York anthropology. This is the New York State Archeological Association. We have been developing the plan for several years and during the month of March instituted the first local branch in the city of Rochester, under the name of Lewis H. Morgan chapter. The plan of organization contemplates



TYPES OF ALGONKIAN PIPES FROM NEW YORK

1 and 2 are from a single grave in Madison county
3 and 4 are typical Cayuga county Algonkian forms

UNIVERSITY OF ILLINOIS LIBRARY



the adherence to scientific methods by collectors, a uniform catalog system, the registration of collectors and an insistence upon the taking of adequate data by every individual member. By means of a state society we are able to unite the interests of those concerned in archeological research and to obtain the results of their field studies. This contributes to the advancement of knowledge.

The association has held several field meetings during the year and has planned a lecture course during the autumn and winter of 1916. It has already taken steps to work in cooperation with the state archeological societies of Wisconsin and Ohio. The present officers are Alvin H. Dewey, president; E. Gordon Lee, secretary, 66 Richland street, Rochester; Edward D. Putnam, treasurer; and John G. D'Olier, vice president. The headquarters of the association are in the State Museum, the Archeologist at present acting as director. This organized effort on the part of citizens to contribute to the extension of the influence of the State Museum and to conserve properly the field of investigation is worthy of attention and some analysis. It marks the beginning of a more efficient, not to say more patriotic, cooperation of the citizen with the institutions that he has created for the benefit of society. By means of the work of the association local museums of archeology will become better supported and their collections fostered with greater care, archeological monuments will not be so ruthlessly destroyed nor will vandals destroy and scatter archeological evidences as heretofore.

Field meetings of the association have been held at the estate of Admiral Hanford, Scottsville, and on the John Dann farm, Honeoye Falls. Under the auspices of Lewis H. Morgan chapter the Archeologist of the State Museum this year delivered the annual address before the federated scientific and historical societies of Rochester at Rochester University. During the year the chapter, which has a membership of about 100, began its plans and collected funds for a memorial arch to Lewis H. Morgan to be erected in Rochester and also requested permission to place a memorial tablet to Morgan in the hall of ethnology in the State Museum.

Needs and recommendations. The work of the archeology section is seriously handicapped by the lack of adequate clerical assistance. We are in need of a stenographer and transcript clerk. With this assistance the efficiency of our office work would be

more than doubled. At present the congestion of work renders any progress in the preparation of manuscripts, the prompt reply to correspondence or the preparation of descriptive booklets for the cases, cumbersome and difficult. Our work is extensive and urgent but without equipment we can not do what should be done. Thus hampered, we are nevertheless doing all that should be expected.

The efficiency of our field investigations would be largely increased if the Archeologist or a representative could be stationed in the field when the weather opens up every spring. Proper field work requires actual presence on the field and an uninterrupted and unhampered research. To bring this about there must be an adequate research fund. With this support we should not only be able to obtain an efficient grasp on our field but also make it productive of far greater results. This is true in both the fields of archeology and ethnology. If the State Museum will not and can not undertake to exploit its field, a field to which it is restricted, other institutions must and will take up the work. During the year field explorations in New York were made by the Museum of the American Indian and by the Andover Academy Expedition, as well as by private collectors.

Observations. In conducting this section there should be no undue concern about obtaining specimens, the primary aim being to advance the knowledge of our subject, and the secondary purpose being to bring back illustrative material. We point out, as an example of this method, the explorations by the Peabody Museum of Harvard, in New York during 1903-6.

Prehistoric Seneca site. A very important Seneca site, from the standpoint of chronology, examined during the year is that situated on the George Reed farm on the terrace above the Hemlock lake outlet, near Richmond Mills, New York. During the past seventy-five years this site has been gone over by collectors who have carried off an incredible amount of material. During the past twenty years excavators have been particularly active and so far no object of European origin has been discovered in any pit or refuse heap.

The Reed Fort site is a sandy arm of the terrace projecting nearly westward into the Hemlock valley. It covers a sloping sandy hill lying between two brooks that have cut deep ravines. The place is a natural fortification since the brooks at the southwest end come within 30 feet of each other, measured from the

rims of their banks. The effect is a natural inclosure easily protected from human and beast enemies. From this upper neck the area gradually expands to a point directly above a fine spring



Map of the Red Fort site, Richmond Mills, Ontario

that flows into a large brook on the north bank. From this point the site gradually tapers down the slope until it reaches a steep knoll the base of which rests in a more level space between the

brooks, which again approach within 40 to 50 feet of it. The brook on the northwest side is shallower at the upper end but quickly eats its way into the shale and plunges over a series of falls until at the lower end of the fortification the banks are 30 to 40 feet in height. The brook on the opposite side is deeper and throughout the length of the hill its depth is 40 to 50 feet with high shaly embankments impossible to climb in places. Along these embankments, particularly at the upper end, the refuse heaps are found scattered over the end of the bank and down the talus slope almost to the bed of the brook; in fact the entire outline of the fortification is nearly bounded by refuse heaps.

The site covers an area of about 5 acres, which was ample space for a considerable Indian village. When the site was cleared about 1850, it was covered with a dense growth of large oak trees, with pines at the lower slope.

The Seneca Indians who frequently passed over this site at the time it was cleared and who frequently hunted, fished and worked in the neighborhood, told the original settlers they had no idea who had lived on the site and the pipes, flints and fragments of pottery were of as much interest to them as to the settlers who opened up the tract.

From this time on antiquarian and amateur archeologists commenced their search for relics and the first spring plowings were always a signal for relic hunters to pick over the surface for finely shaped flints, pipes and shell and bone trinkets. During recent years the most successful collectors so far as we know have been Mr Alva Reed, Mr Joseph Mattern of West Rush; Mr Alvin H. Dewey, Mr H. C. Follett and Mr George Mills of Rochester; and Mr Frederick Houghton of Buffalo. A large share of the material found by individual collectors is in the New York State Museum collection. No burials were found until 1912, when Mr Frederick Houghton, excavating for the Buffalo Society of Natural Sciences, found a burial site on the projecting nose across the ravine east of the spring and nearly opposite the falls. Our examination of this site made in 1905, 1910, 1911 and 1916, resulted in the series of notes here given.

It was found that the soil in nearly every portion of the site was deeply stained and that there were natural depressions irregular in shape that seem to have been used as refuse dumps. Even after much cultivation for farming purposes, the soil still shows blackened areas that outline the village dumps. Some of these

pits and deposits are 6 or more feet in depth and filled with broken stone, ashes, animal bones and broken implements with an occasional fine specimen in good condition. As we have previously stated, the larger deposits were along the northeast bank, sloping toward the falls. In many of these sidehill dumps the ashes are several feet in thickness and have led some excavators to think that the site was occupied for a prolonged period. Our opinion is, however, that a village of one hundred to one hundred fifty people occupying this site for ten years would produce the amount of ash found in the dumps, especially if refuse as well as fuel had been consumed.

The present appearance of the site is that of a sloping sandy hill edged by ravines and fringed with trees. The brooks flow the year around and the larger one has a considerable fall over which the farm owners have built a bridge. Above the falls it is possible to walk along the edge of the brook and up the ravine for a considerable distance. The ravine is wide and has a flat bottom which gives ample space for the meandering of the stream. Near the upper end of the fort from the base a natural trail runs up the embankment along the projecting nose, but access is not easy from any other point. Along this embankment from the falls southward and up the ravine the débris may be seen mixed with the talus. An excavation reveals quantities of animal bones, broken pottery and fragments of implements.

From the lower end of the fortification the trail runs down to a sloping flat that gradually leads to the valley level. From this point it is about one-fourth of a mile to the Hemlock outlet.

The character of the implements found on the site are without question prehistoric Iroquoian and presumably Senecan. Sites to the northeast on the Alva Reed farm are non-Iroquoian, as are most of the contiguous sites where relics are found in any quantity.

XI

STAFF OF THE DEPARTMENT OF SCIENCE

The members of the staff, permanent and temporary, of the Department of Science as at present constituted are:

ADMINISTRATION

John M. Clarke, Director
 Jacob Van Deloo, Director's Clerk
 Edwin J. Stein, Stenographer

GEOLOGY AND PALEONTOLOGY

John M. Clarke, State Geologist and Paleontologist
 David H. Newland, Assistant State Geologist, *Curator of Geology*
 Rudolf Ruedemann, Assistant State Paleontologist, *Curator of Paleontology*
 William L. Bryant, Honorary Custodian of Fossil Fishes
 C. A. Hartnagel, Assistant in Geology, *Curator of Stratigraphy*
 Robert W. Jones, Assistant in Economic Geology, *Assistant Curator of Industrial Geology*
 Herbert P. Whitlock, Mineralogist, *Curator of Mineralogy*
 George S. Barkentin, Draftsman
 Noah T. Clarke, Technical Assistant
 Winifred Goldring, Assistant in Paleontology
 H. C. Wardell, Preparator, *Assistant Curator of Paleontology*
 Theodore J. Lipsky, Stenographer
 Charles P. Heidenrich, Mechanical Assistant
 Joseph J. Bylancik, Clerk
 John L. Casey, Custodian
 William Rausch, Cabinet Maker
 Jerry Hayes, Laborer

*Temporary experts**Areal geology*

Prof. H. P. Cushing, Adelbert College
 Prof. W. J. Miller, Smith College
 Prof. G. H. Hudson, Plattsburg State Normal School
 Dr W. O. Crosby, Massachusetts Institute of Technology
 Prof. George H. Chadwick, St Lawrence University
 Prof. John L. Rich, University of Illinois
 Dr A. F. Buddington, Princeton University

Geographic geology

Prof. Herman L. Fairchild, University of Rochester

Prof. James H. Stoller, Union College

BOTANY

Homer D. House, State Botanist

Joseph Rubinger, Assistant, *Curator of Botany*

ENTOMOLOGY

Ephraim P. Felt, State Entomologist

D. B. Young, Assistant State Entomologist, *Curator of Entomology*

Fanny T. Hartman, Assistant, *Assistant Curator of Entomology*

Anna M. Tolhurst, Stenographer

William A. J. Tracy, Page

ZOOLOGY

Sherman C. Bishop, Zoologist, *Curator of Zoology*

Benjamin Walworth Arnold, Honorary Curator of Ornithology

Arthur Paladin, Taxidermist

Temporary expert

Dr H. A. Pilsbry, Philadelphia

ARCHEOLOGY

Arthur C. Parker, Archeologist, *Curator of Archeology and
Ethnology*

Temporary assistant

Howard A. Lansing, Albany

XII

ACCESSIONS TO THE COLLECTIONS

ECONOMIC GEOLOGY

Collection

Hartnagel, C. A., Albany	
Zinc ore from Canajoharie.....	1
Newland, D. H., Albany	
Rutile ores from Roseland, Va.....	5
Ilmenite from near Galax, Va.....	10
Pyrrhotite from near Galax, Va.....	1
Graphite and wall rocks, Adirondacks.....	17
Magnetite and country rocks from Sterlington, N. Y.....	15
Zinc ores and country rocks from Edwards, N. Y.....	40

Donation

Robert Geer & Son, Albany	
Large block of crystallized solar salt.....	1
New York State Highway Department	
Samples illustrating physical testing of cement.....	16
Binn, Prof. Charles S., Alfred	
Burned clay samples showing shrinkage.....	12

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MINERALOGY

Donation

Emerson, Prof. B. K., Amherst, Mass.	
Fluorite, Westmoreland, N. H.....	3
Molybdenite, Westmoreland, N. H.....	1
Wulfenite, Lendville, Mass.....	1
Anhydrite, Hadley, Mass.....	1
Crocidolite, Bondville, Mass.....	1
Datolite, Westfield, Mass.....	1
Corundum, Pelham, Mass.....	1
Amphibole (asbestos), Pelham, Mass.....	1
Vermiculite, Pelham, Mass.....	1
Rutile, Graves Mt., Ga.....	3
Rutile (large), Graves Mt., Ga.....	1
Psilomelane, Cary Empire Mine, Ga.....	2
Cinnabar in opal, Almadencito, Mexico.....	3
Lazulite, Graves Mt., Ga.....	1
Staurolite, Farrington, Ga.....	11
Zoisite, Poultney, Vt.....	1
Diaspore, Chester, Mass.....	1
Columbite, Portland, Conn.....	1

Titanite, Renfrew, Canada.....	1
Serpentine, Washington, Ga.....	1
Opal (tripolite), Dacres, South Africa.....	1
Serpentine, Havana, Cuba.....	1
Vanquelinite (elroquite), Elroque, West Indies.....	2
Apatite (rock phosphate), Charleston, S. C.....	1
Apatite (rock phosphate), Mona, West Indies.....	3
Apatite (rock phosphate), Dunellen, Fla.....	1
Serpentine (menelite), Beaufort, S. C.....	1
Wait, Charles, Crown Point	
Fluorite in microcline, Crown Point, N. Y.....	3
Newland, D. H., Albany	
Ilmenite, Galax, Va.....	1
Mathis, William, Feura Bush	
Quartz (crystal), Feura Bush, N. Y.....	1

Exchange

Utman, J. C., Ashland, Wis.	
Hematite, Ironwood, Mich.....	12
Psilomelane, Ironwood, Mich.....	6
Limonite, Ironwood, Mich.....	3
Psilomelane, Hurley, Wis.....	1
Hematite after goethite, Ironwood, Mich.....	1
Pyrolusite on psilomelane, Hurley, Wis.....	1
Manganite, Ironwood, Mich.....	1
Xanthosiderite, Ironwood, Mich.....	1
Goethite on psilomelane, Ironwood, Mich.....	1
Copper, Calumet, Mich.....	1
Barite, Bessimer, Mich.....	2
Aragonite, Ironwood, Mich.....	2
Calcite, Ontonagon, Mich.....	1
Calcite and copper, Hancock, Mich.....	1
Calcite and stilbite, Mass, Mich.....	1
Glenn, M. L., Erie, Pa.	
Alunite, Fire Clay City, Utah.....	1
Anorthoclase, Essex co., N. J.....	1
Stevensite, Essex co., N. J.....	1
Ankerite, 18 Mile Creek, Erie co., N. Y.....	1
Amphibole, Berkeley, Cal.....	1
Semseyite, Kisbanya, Hungary.....	1
Halotrichite, Erie, Pa.....	3
Fitts, William L., Springfield, Mass.	
Datolite, Westfield, Mass.....	6

Purchase

Law, Edward S., Charlemont, Mass.	
Ankerite, Hawley, Mass.....	1

PALEONTOLOGY

Donation

Arnold, Benjamin Walworth , Albany	
Trenton cephalopods from Fossil island 15 miles north of Manitoulin island, Canada.....	7
Bostock, Lillian D. , New York	
Pygidium of <i>Dalmanites perceensis</i> Clarke, Grande Grève limestone, Percé Rock, P. Q., Canada.....	1
Halsey, William D. , Bridgehampton	
<i>Arca transversa</i> , Pleistocene, Bridgehampton.....	22
<i>Venus</i> sp.....	3
<i>Crepidula formacata</i>	8
<i>Columbella lunata</i>	1
Undetermined lamellibranchs	3
Hudson, Prof. G. H. , Plattsburg	
Cephalopods from Lowville limestone, north end of Valcour island	8
Johnston, John S. , Wellsville	
Fossil sponge from Chemung sandstone, Hinsdale.....	1
Kinnear, W. T. , Kirkbuddo by Forfar, Scotland	
The following from the Middle Old Red Sandstone:	
<i>Palaeospondylus gunni</i> Traquair and	
<i>Mesocanthus peachi</i> Traquair (on one slab).....	1
<i>Palaeospondylus gunni</i> Traquair.....	2
Lewi, Dr W. G.	
Sponge boring in brachiopod, Berne, N. Y.....	2
McGill University Museum , Montreal, Canada	
<i>Baropezia</i> (<i>Sauropus</i>) <i>sydnensis</i> Dawson, Coal Measures, Sydney, C. B. Cast from original in McGill University. Type	
Acadian Geology, Dawson (1878), p. 358, fig. 140.	
Price, W. Armstrong	
<i>Clionolithes canna</i> Price, from Conemaugh series, Brush Creek limestone, Preston co., W. Va.....	1
<i>Clionolithes canna</i> (in shell of <i>Derbya crassa</i>) (Meek & Hayden) from Pottsville series, Kanawha group, Winifrede limestone, Raleigh co., W. Va.	1

Exchange

Buffalo Society of Natural History , Buffalo	
<i>Cladoselache fylleri</i> Newberry, Cleveland shale, Lindale, Ohio	1
<i>Eurypterus pittsfordensis</i> Sarle, Pittsford shale (Salina), Pittsford, N. Y.....	2
Greger, D. K. , Columbia, Mo.	
Trilobites from Louisiana limestone, Chouteau, Mo.....	30

Purchase

Luther, D. D. , Naples	
Fossils from various formations, mostly western New York....	475
Crinoids mostly from Keokuk group, Crawfordsville, Indiana....	22

Plourde, Anthony

Fossil fishes (Devonic) from Migouasha, P. Q., Canada..... 84

Ward's Natural Science Establishment, Rochester*Olenellus thompsoni*, Lower Cambrian, Lancaster co., Pa.. 8*Neolenus serratus* Rom., Middle Cambrian, Mount Stephen,
B. C. 2*Ptychoparia cordillerae* Roemer, Middle Cambrian,
Mount Stephen, B. C..... 1*Bathyriscus rotundatus* Rom., Middle Cambrian,
Mount Stephen, B. C..... 1*Streptelasma strictum*, Port Ewen beds, Port Ewen... 1*Eatonia medialis* var., Port Ewen beds, Port Ewen.... 1*Schuchertella woolworthana*, Port Ewen beds, Port
Ewen 1*Stenocisma acutiplicatum*, Port Ewen beds, Port Ewen 3Slab of Esopus shale with *Leptocoelia flabellites*... 1The following fossils from the Acadian (Burgess) Burgess Pass,
near Field, British Columbia:*Marrella splendens* Walcott..... 1*Ottoia prolifica* Walcott..... 1*Eldonia ludwigi* Walcott..... 1*Hymenocaris perfecta* Walcott..... 1

Grande Grève limestone fossils from Grande Grève, P. Q., Canada..1700

Mastodon bones found near Perkinsville

*Collection***Clarke, John M., Albany**Part of a pygidium of *Dalmanites perceensis*, from Grande
Grève, Percé, P. Q., Canada. This pygidium is 5 feet 7 inches long
and 8 inches wide at anterior margin; the original complete trilobite
was probably 22½ inches long..... 1**Ruedemann, Rudolf, Albany**Utica, Lorraine and Frankfort fossils from Mohawk and Black
River valleys, Lorraine gulf and Pulaski region.....2000

ZOOLOGY

Donation

Birds

Conway, Mrs M. J., TroyGreen heron, *Butorides virescens* (Linn.)..... 1Killdeer plover, *Oxyechus vociferus* (Linn.)..... 1Ruffed grouse, *Bonasa umbellus* (Linn.)..... 1Short-eared owl, *Asio flammeus* (Pont.)..... 3Screech owl, *Otus asio* (Linn.)..... 4Sharp-shinned hawk, *Accipiter velox* (Wilson)..... 1Blue jay, *Cyanocitta cristata* (Linn.)..... 1Fox sparrow, *Passerella iliaca* (Merrem)..... 1Robin, *Planesticus migratorius* (Linn.)..... 1

Schell, Elvira A., Albany

Case of twelve foreign birds.

Edwards, Harriet A., Port Henry

Herring gull, *Larus argentatus* Pont..... 1

Dewey, Melvil, Lake Placid

Goldfinch, *Geothlypis trichas* (Linn.)..... 1

Ruby-throated hummingbird, *Archilochus colubris* (Linn.) 1

Little, Miss E. E., Menands

Red-shouldered hawk, *Buteo lineatus* (Gmel.)..... 1

Conservation Commision, Albany

Rose-breasted grosbeak, *Zamelodia ludoviciana* (Linn.).... 1

Birds' Nests

Conway, Mrs M. J., Troy

Kingbird, *Tyrannus tyrannus* (Linnaeus)..... 1

Alder flycatcher, *Empidonax trailli alnorum* Brewster.. 1

Least flycatcher, *Empidonax minimus* (W. M. & S. F. Baird). 3

Bobolink, *Dolichonyx oryzivorus* (Linnaeus)..... 1

Red-winged blackbird, *Agelaius phoeniceus* (Linnaeus). 1

Orchard oriole, *Icterus spurius* (Linnaeus)..... 1

Baltimore oriole, *Icterus galbula* (Linnaeus)..... 2

Goldfinch, *Astragalinus tristis* (Linnaeus)..... 4

Arkansas goldfinch, *Astragalinus psaltria psaltria*
(Say)..... 1

Vesper sparrow, *Poecetes gramineus* (Gmelin)..... 4

Grasshopper sparrow, *Ammodramus savannarum aus-*
tralis Maynard..... 1

Chipping sparrow, *Spizella passerina* (Bechstein)..... 2

Field sparrow, *Spizella pusilla* (Wilson)..... 4

Indigo bunting, *Passerina cyanea* (Linnaeus)..... 8

Cedar waxwing, *Bombycilla cedrorum* (Vieillot)..... 3

Migrant shrike, *Lanius ludovicianus migrans* (Palmer) 1

Red-eyed vireo, *Vireosylva olivacea* (Linnaeus)..... 11

Warbling vireo, *Vireosylva gilva* (Vieillot)..... 3

Bells vireo, *Vireo belli* Audubon..... 1

Yellow warbler, *Dendroica aestiva* (Gmelin)..... 12

Chestnut-sided warbler, *Dendroica pennsylvanica* (Lin-
naeus) 1

Yellow-breasted chat, *Icteria virens* (Linnaeus)..... 1

Redstart, *Setophaga ruticilla* (Linnaeus)..... 8

Catbird, *Dumetella carolinensis* (Linnaeus)..... 2

Brown thrasher, *Toxostoma rufum* (Linnaeus)..... 1

Long-billed marsh wren, *Telmatodytes palustris* (Wil-
son)..... 6

Chickadee, *Penthestes atricapillus* (Linnaeus)..... 2

California bush-tit, *Psaltriparus minimus californi-*
cus Ridgway..... 1

Wood thrush, *Hylocichla mustelina* (Gmelin)..... 1

Veery, *Hylocichla fuscescens* (Stephens)..... 1

Birds' Eggs

Conway, Mrs. M. J., Troy	No. of sets
Western grebe, <i>Aechmophorus occidentalis</i> (Lawrence)...	1
Eared grebe, <i>Colymbus nigricollis californicus</i> (Heermann).....	1
Puffin, <i>Fratercula arctica</i> (Linnaeus).....	1
Murre, <i>Uria troille</i> (Linnaeus).....	3
California murre, <i>Uria troille californica</i> (H. Bryant)...	1
Razor-billed auk, <i>Alca torda</i> Linnaeus.....	1
Kittiwake, <i>Rissa tridactyla</i> (Linnaeus).....	1
Iceland gull, <i>Larus leucopterus</i> Faber.....	1
Black-backed gull, <i>Larus marinus</i> Linnaeus.....	1
Herring gull, <i>Larus argentatus</i> Pontoppidan.....	2
Ring-billed gull, <i>Larus delawarensis</i> Ord.....	1
Mew gull, <i>Larus delawarensis</i> Ord.....	1
Franklin gull, <i>Larus franklini</i> Richardson.....	2
Forster tern, <i>Sterna forsteri</i> Nuttall.....	1
Common tern, <i>Sterna hirundo</i> Linnaeus.....	1
Arctic tern, <i>Sterna paradisea</i> Brunnich.....	1
Roseate tern, <i>Sterna dougalli</i> Montagu.....	1
Least tern, <i>Sterna antillarum</i> (Lesson).....	1
Sooty tern, <i>Sterna fuscata</i> Linnaeus.....	1
Black tern, <i>Hydrochelidon nigra surinamensis</i> (Gmelin).....	1
White-winged black tern, <i>Hydrochelidon leucoptera</i> (Temminck).....	1
Noddy tern, <i>Anous stolidus</i> (Linnaeus).....	1
Black Skimmer, <i>Rynchops nigra</i> Linnaeus.....	1
Fulmar, <i>Fulmarus glacialis</i> (Linnaeus).....	1
Leach petrel, <i>Oceanodroma leucorhoa</i> (Vieillot).....	1
Gannet, <i>Sula bassana</i> (Linnaeus).....	1
Common cormorant, <i>Phalacrocorax carbo</i> (Linnaeus)...	1
Double-crested cormorant, <i>Phalacrocorax auritus</i> (Lesson)	1
Farallon cormorant, <i>Phalacrocorax auritus albociliatus</i> Ridgway	1
Brandt's cormorant, <i>Phalacrocorax penicillatus</i> (Brandt)	1
Green-winged teal, <i>Nettion carolinense</i> (Gmelin).....	1
Blue-winged teal, <i>Querquedula discors</i> (Linnaeus).....	1
Redhead duck, <i>Marila americana</i> (Eyton).....	1
Trumpeter swan, <i>Olor buccinator</i> (Richardson) laid in captivity	6
White ibis, <i>Guara alba</i> (Linnaeus).....	1
White-faced glossy ibis, <i>Plegadis guarauna</i> (Linnaeus)...	1
Least bittern, <i>Ixobrychus exilis</i> (Gmelin).....	1
Great blue heron, <i>Ardea herodias</i> Linnaeus.....	1
Snowy heron, <i>Egretta candidissima</i> (Gmelin).....	1

	No. of sets
Louisiana heron, <i>Hydranassa tricolor ruficollis</i> (Gosse)	1
Little blue heron, <i>Florida caerulea</i> (Linnaeus)	1
Green heron, <i>Butorides virescens</i> (Linnaeus)	1
Black-crowned night heron, <i>Nycticorax nycticorax naevius</i> (Boddaert)	1
King rail, <i>Rallus elegans</i> Audubon	1
Sora rail, <i>Porzana carolina</i> (Linnaeus)	1
Florida gallinule, <i>Gallinula galeata</i> (Lichtenstein)	2
Northern phalarope, <i>Lobipes lobatus</i> (Linnaeus)	1
Black-necked stilt, <i>Himantopus mexicanus</i> (Müller)	1
Spotted sandpiper, <i>Actitis macularia</i> (Linnaeus)	1
European curlew, <i>Numenius numenius</i> (Brisson)	1
Whimbrel, <i>Numenius phaeopus</i> (Linnaeus)	1
Lapwing, <i>Vanellus vanellus</i> (Linnaeus)	1
European golden plover, <i>Charadrius apricarius</i> Linnaeus	1
Killdeer plover, <i>Oxyechus vociferus</i> (Linnaeus)	1
Ringed plover, <i>Aegialitis hiaticula</i> (Linnaeus)	1
Pea fowl, <i>Pavo cristatus</i> Linnaeus	1
Valley quail, <i>Lophortyx californica vallicola</i> (Ridgway)	2
Prairie chicken, <i>Tympanuchus americanus</i> (Reichenbach)	1
Mourning dove, <i>Zenaidura macroura carolinensis</i> (Linnaeus)	1
Cooper hawk, <i>Accipiter cooperi</i> (Bonaparte)	1
Red-shouldered hawk, <i>Buteo lineatus</i> (Gmelin)	1
Sparrow hawk, <i>Falco sparverius</i> Linnaeus	3
Desert sparrow hawk, <i>Falco sparverius phalaena</i> (Lesson)	1
Screech owl, <i>Otus asio</i> (Linnaeus)	1
Burrowing owl, <i>Speotyto cunicularia hypogaea</i> (Bonaparte)	1
Yellow-billed cuckoo, <i>Coccyzus americanus</i> (Linnaeus).	2
Black-billed cuckoo, <i>Coccyzus erythrophthalmus</i> (Wilson)	1
Downy woodpecker, <i>Dryobates pubescens medianus</i> (Swainson)	1
Red-headed woodpecker, <i>Melanerpes erythrocephalus</i> (Linnaeus)	1
Flicker, <i>Colaptes auratus luteus</i> Bangs	3
Red-shafted flicker, <i>Colaptes cafer collaris</i> Vigors	1
Nighthawk, <i>Chordeiles virginianus</i> (Gmelin)	1
Black-chinned hummingbird, <i>Archilochus alexandri</i> (Bourcier & Mulsant)	1
Anna's hummingbird, <i>Calpte anna</i> (Lesson)	1
Allen hummingbird, <i>Selasphorus alleni</i> Henshaw	1
Scissor-tailed flycatcher, <i>Muscivora forficata</i> (Gmelin) ..	1
Kingbird, <i>Tyrannus tyrannus</i> (Linnaeus)	7

	No. of sets
Arkansas kingbird, <i>Tyrannus verticalis</i> Say.....	1
Crested flycatcher, <i>Myiarchus crinitus</i> (Linnaeus).....	1
Phoebe, <i>Sayornis phoebe</i> (Latham).....	8
Black phoebe, <i>Sayornis nigricans</i> (Swainson).....	1
Western wood pewee, <i>Myiochanes richardsoni</i> (Swainson)	1
Alder flycatcher, <i>Empidonax trailli alnorum</i> Brewster.	2
Least flycatcher, <i>Empidonax minimus</i> (W. M. & S. F. Baird)	1
Prairie horned lark, <i>Otocoris alpestris praticola</i> Henshaw	1
Magpie, <i>Pica pica hudsonia</i> (Sabine).....	1
Blue jay, <i>Cyanocitta cristata</i> (Linnaeus).....	2
Long-crested jay, <i>Cyanocitta stelleri diademata</i> (Bonaparte)	1
California jay, <i>Aphelocoma californica</i> (Vigors)....	1
Crow, <i>Corvus brachyrhynchos</i> Brehm.....	10
Starling, <i>Sturnus vulgaris</i> Linnaeus.....	1
Bobolink, <i>Dolichonyx oryzivorus</i> (Linnaeus).....	3
Cowbird, <i>Molothrus ater</i> (Boddaert) (Eggs).....	10
Dwarf cowbird, <i>Molothrus ater obscurus</i> (Gmelin)....	1
Yellow-headed blackbird, <i>Xanthocephalus xanthocephalus</i> (Bonaparte)	1
Red-winged blackbird, <i>Agelaius phoeniceus</i> (Linnaeus).	8
Bicolored red-wing, <i>Agelaius gubernator californicus</i> Nelson	2
Tricolored red-wing, <i>Agelaius tricolor</i> (Audubon).....	2
Meadowlark, <i>Sturnella magna</i> (Linnaeus).....	1
Western meadowlark, <i>Sturnella neglecta</i> Audubon.....	1
Arizona hooded oriole, <i>Icterus cucullatus nelsoni</i> Ridgway	1
Orchard oriole, <i>Icterus spurius</i> (Linnaeus).....	1
Baltimore oriole, <i>Icterus galbula</i> (Linnaeus).....	2
Brewer's blackbird, <i>Euphagus cyanocephalus</i> (Wagler).	2
Purple grackle, <i>Quiscalus quiscula quiscula</i> (Linnaeus)	5
Housefinch, <i>Carpodacus mexicanus frontalis</i> (Say).	1
Goldfinch, <i>Astragalinus tristis</i> (Linnaeus).....	2
English sparrow, <i>Passer domesticus</i> Linnaeus.....	3
Arkansas goldfinch, <i>Astragalinus psaltria</i> (Say).....	1
Vesper sparrow, <i>Pooecetes gramineus</i> (Gmelin).....	3
Grasshopper sparrow, <i>Ammodramus savannarum australis</i> Maynard	1
Lark sparrow, <i>Chondestes grammacus</i> (Say).....	1
Chipping sparrow, <i>Spizella passerina</i> (Bechstein).....	12
Field sparrow, <i>Spizella pusilla</i> (Wilson).....	1
Song sparrow, <i>Melospiza melodia</i> (Wilson).....	42
Heermann's song sparrow, <i>Melospiza melodia heermanni</i> Baird	1
Towhee, <i>Pipilo erythrophthalmus</i> (Linnaeus).....	2

	No. of sets
Anthony's towhee, <i>Pipilo crissalis senicula</i> Anthony..	1
Cardinal, <i>Cardinalis cardinalis</i> (Linnaeus).....	1
Gray-tailed cardinal, <i>Cardinalis cardinalis canicaudus</i> Chapman	1
Rose-breasted grosbeak, <i>Zamelodia ludoviciana</i> (Linnaeus)	1
Black-headed grosbeak, <i>Zamelodia melanocephala</i> (Swainson)	2
Indigo bunting, <i>Passerina cyanea</i> (Linnaeus).....	3
Dickcissel, <i>Spiza americana</i> (Gmelin).....	2
Scarlet tanager, <i>Piranga erythromelas</i> Vieillot.....	1
Cliff swallow, <i>Petrochelidon lunifrons</i> (Say).....	1
Barn swallow, <i>Hirundo erythrogastra</i> Boddaert.....	1
Tree swallow, <i>Iridoprocne bicolor</i> (Vieillot).....	1
Bank swallow, <i>Riparia riparia</i> (Linnaeus).....	3
Rough-winged swallow, <i>Stelgidopteryx serripennis</i> (Audubon)	1
Cedar waxwing, <i>Bombycilla cedrorum</i> Vieillot.....	3
California shrike, <i>Lanius ludovicianus gambeli</i> Ridgway	1
Migrant shrike, <i>Lanius ludovicianus migrans</i> Palmer..	2
Red-eyed vireo, <i>Vireosylva olivacea</i> (Linnaeus).....	2
Warbling vireo, <i>Vireosylva gilva</i> (Vieillot).....	1
Bell's vireo, <i>Vireo belli</i> Audubon.....	2
White-eyed vireo, <i>Vireo griseus</i> (Boddaert).....	1
Worm-eating warbler, <i>Helmitheros vermivorus</i> (Gmelin)	1
Yellow warbler, <i>Dendroica aestiva</i> (Gmelin).....	4
Black-throated green warbler, <i>Dendroica virens</i> (Gmelin).	1
Oven-bird, <i>Seiurus aurocapillus</i> (Linnaeus).....	1
Yellow-breasted chat, <i>Icteria virens</i> (Linnaeus).....	1
Long-tailed chat, <i>Icteria virens longicauda</i> Lawrence..	1
Hooded warbler, <i>Wilsonia citrina</i> (Boddaert).....	1
Redstart, <i>Setophaga ruticilla</i> (Linnaeus).....	4
Meadow pipit, <i>Anthus pratensis</i> (Linnaeus).....	1
Dipper, <i>Cinclus mexicanus</i> Swainson.....	1
Mockingbird, <i>Mimus polyglottos</i> (Linnaeus).....	1
Catbird, <i>Dumetella carolinensis</i> (Linnaeus).....	16
Brown thrasher, <i>Toxostoma rufum</i> (Linnaeus).....	1
California thrasher, <i>Toxostoma redivivum</i> (Gambel).....	1
House wren, <i>Troglodytes aedon</i> (Vieillot).....	1
Long-billed marsh wren, <i>Telmatodytes palustris</i> (Wilson)	2
Chickadee, <i>Penthestes atricapillus</i> (Linnaeus).....	1
California bush-tit, <i>Psaltriparus minimus californicus</i> Ridgway	2
Wood thrush, <i>Hylocichla mustelina</i> (Gmelin).....	7
Veery, <i>Hylocichla fuscescens</i> (Stephens).....	4
Robin, <i>Planesticus migratorius</i> (Linnaeus).....	11
Western robin, <i>Planesticus migratorius propinquus</i> (Ridgway)	2
Bluebird, <i>Sialia sialis</i> (Linnaeus).....	14

Mammals

Conway, Mrs M. J., Troy	
Mink, <i>Mustela vison</i> Schreber.....	I
New York Aquarium	
Bottle-nosed dolphin, <i>Tursiops truncatus</i> (Mont.).....	I
Downing, Dr A. S., Albany	
Skunk, <i>Mephitis putida</i> Boitard.....	I
Conservation Commission, Albany	
Virginia deer (fawns) <i>Odocoileus virginianus</i> (Auct.)..	2

Reptiles and Batrachians

Albee, Mrs M. E., Mohawk	
Milk snake, <i>Lampropeltis doliiatus triangulus</i> (Boie)	I
Clarke, N. T., Albany	
Cricket frog, <i>Acris gryllus</i> LeConte.....	I
Newt, <i>Diemictylus viridescens</i> Raf.....	I
Casey, George W., Elsmere	
Bullfrog, <i>Rana catesbiana</i> Shaw.....	I

Invertebrates

Araneida

Clarke, N. T., Albany	
<i>Araneus sericatus</i> Clerck.....	I
<i>Dolomedes fontanus</i> Emerton.....	I
<i>Araneus patagiatus</i> Clerck.....	I
Stoddard, Miss A. G., Dunkirk	
<i>Araneus cornutus</i> Clerck	
<i>Araneus sericatus</i> Clerck	
<i>Araneus trifolium</i> (Hentz)	
<i>Araneus marmoreus</i> Clerck	
Lansing, Howard A., Menands	
<i>Araneus benjaminus</i> (Walckenaer).....	I
Conway, Mrs M. J., Troy	
Horseshoe crab, <i>Xiphosura polyphemus</i> Brunnich.....	I
Gunn, Elmer D., Albany	
Squid, <i>Loligo pealeii</i> Lesueur.....	I

Exchange

Birds

Victoria Memorial Museum, Ottawa, Canada	
Gannea, <i>Sula bassana</i> (Linn.).....	3
Razor-billed auk, <i>Alca torda</i> Linn.....	I
Black guillemot, <i>Cephus grylle</i> (Linn.).....	2
Puffin, <i>Fratercula arctica</i> (Linn.).....	I
Common murre, <i>Uria troille</i> (Linn.).....	2

Purchase

Amphibian casts

Franklin, Dwight, New York

Toad, <i>Bufo americanus</i> LeConte.....	2
Tree toad, <i>Hyla versicolor</i> LeConte.....	2
Pickrel frog, <i>Rana palustris</i> LeConte.....	1
Marbled salamander, <i>Amblystoma opacum</i> (Graveu.)....	2
Newt, <i>Diemictylus viridescens</i> Raf.....	1
Newt, red land stage, <i>Diemictylus viridescens</i> Raf.....	1
Mud puppy, <i>Necturus maculatus</i> Raf.....	1

Domestic Pigeons

Hartley, B. M., West Haven, Conn.

Priest	2
Bluejesses	2
Hungarian hen	2
Ice pigeon	2
White king	2
Satinette	2
Polish lynx	2
Black barb	2
English carrier (black).....	2
Mokee (narrow tailed).....	2
Frillback	2
Turbiteen	2
White English pouter.....	2
Saubian	2
Turbit	2

Mammals

Boyd, Harold, Rensselaer, N. Y.

Woodchuck, <i>Marmota monax rufescens</i> Howell.....	5
Skunk, <i>Mephitis putida</i> (Shaw).....	1

Collection

Birds

Bank swallow, <i>Riparia riparia</i> (Linn.) ad.....	3
Bank swallow, <i>Riparia riparia</i> (Linn.) yg.....	8
Nests, Bank swallow, <i>Riparia riparia</i> (Linn.).....	3
Eggs, Bank swallow, <i>Riparia riparia</i> (Linn.).....	5
Robin, <i>Planesticus migratorius</i> (Linn.).....	3
Nest, <i>Planesticus migratorius</i> (Linn.).....	1

Mammal

Bat, <i>Eptesicus fuscus</i> (Beau.).....	1
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Reptiles

Summer snake, <i>Liopeltis vernalis</i> (DeKay).....	1
Peeper, <i>Hyla pickeringii</i> Storer.....	3
Cricket frog, <i>Acris gryllus</i> LeConte.....	1

Arachnida

Araneida

List of species

<i>Theridion montanum</i> Emerton
<i>Theridion frondeum</i> Hentz
<i>Theridion murarium</i> Emerton
<i>Theridion sexpunctatum</i> Emerton
<i>Theridion tepidarium</i> C. Koch
<i>Ceratinella brunnea</i> Emerton
<i>Prosopotheca communis</i> (Emerton)
<i>Bathyphantes nigrinus</i> (Westring)
<i>Bathyphantes alpinus</i> Emerton
<i>Bathyphantes zebra</i> Emerton
<i>Linyphia insignis</i> Blackwall
<i>Linyphia phrygiana</i> C. Koch
<i>Linyphia marginata</i> C. Koch
<i>Linyphia communis</i> Hentz
<i>Linyphia pusilla</i> Sundevall
<i>Linyphia nearctica</i> Banks
<i>Tmeticus armatus</i> Banks
<i>Oedothorax montanus</i> (Emerton)
<i>Oedothorax bidentatus</i> (Emerton)
<i>Oedothorax microtarsus</i> (Emerton)
<i>Araneus trifolium</i> (Hentz)
<i>Araneus marmoreus</i> Clerck
<i>Araneus sericatus</i> Clerck
<i>Araneus angulatus</i> Clerck
<i>Araneus patagiatus</i> Clerck
<i>Araneus cornutus</i> Clerck
<i>Araneus cucurbitinus</i> Clerck
<i>Araneus corticarius</i> (Emerton)
<i>Araneus labyrinthicus</i> (Hentz)
<i>Araneus arabescus</i> (Walckenaer)
<i>Argiope trifasciata</i> (Forsk.)
<i>Argiope aurantia</i> Lucas
<i>Tetragnatha laboriosa</i> Hentz
<i>Eucta lacerta</i> (Walckenaer)
<i>Dictyna foliacea</i> (Hentz)
<i>Agelena naevia</i> Walckenaer
<i>Cicurina brevis</i> (Emerton)
<i>Cryphoea montana</i> Emerton
<i>Pirata minutus</i> Emerton
<i>Pardosa distincta</i> (Blackwall)
<i>Pardosa mackenziana</i> (Keyserling)
<i>Castaneira descripta</i> (Hentz)

Clubiona canadensis Emerton
Neon nellii Peckham
Evarcha hoyi (Peckham)
Pellenes decorus (Blackwall)
Sitticus palustris (Peckham)
Dendryphantes marginatus (Walckenaer)
Dendryphantes mccooki (Peckham)
Misumena vatia (Clerck)
Liocranum calcaratum Emerton
Dolomedes sp. im.
Steatoda borealis (Hentz)
Erigone sp.
Phalangida

List of species taken

Oligolophus pictis (Wood)
Mitopus montanus (Banks)
Leiobunum vittatum (Say)
Leiobunum politum Weed.
Leiobunum calcar (Wood)
Leiobunum nigropalpi (Wood)

ARCHEOLOGY

Purchase

E. P. Bouton, jr

Shell gorget

Ward's Natural Science Establishment

(Articles from Richmond Mills)

Bone awls	65
Fish plate	
Bone needle fragments	11
Bone chisels	4
Bone punches	9
Tubular bone tool	1
Raccoon penis bones	4
Bone harpoon	1
Digging tools	2
Bone spatula	1
Parts of skeleton	
Patella bone	1
Cupped stone	

(Articles from Lima, Tram site)

Gun barrel fragment	1
Pestle and fragment	2
Battering stone	1
Grooved axe	4
Celts and fragments	10
Hammer stones	6
Net sinkers	2
Stone natural perforation	1
Small polished stone	1

Gouge	1
Worked stone	1
Adz	1
Beads, strung	800
Pottery fragments	40
Tray containing beads and metal objects	10
Bone fish hooks	2
Clay pipe fragments	4
Iron axe heads	3
Iron side plates of musket	2
Iron knife blades	3
Metallic fragments in tray, European	5
Juvenile lower jaw	2
Tray containing animal teeth and beads	

Donation

W. R. Blackie, Williamsbridge

Stone grooved axe	1
Arrow points	5
Scrapers	3
Bone punch	

H. L. Bowers

Clay pipes	2
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Leona Babcock

Glacial pebble	1
Wooden scoop or ladle	1

A. A. Schmidt

Pestle, cylindrical	1
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E. H. Gohl, Auburn

Clay pipe	1
Arrow point	1
Clay pipe fragments	
Phalanx	1
Bone awl	1
Bone needle fragment	1
Unio shell	1
Potters clay	1
Tempering stone	1
Net sinkers	8
Hammer stones	1
Muller, broken	1
Potsherds	35
Sections of clay pots	2
Section long neck clay vessel	10
Sections clay pots	7

Exchange

American Museum of Natural History, New York

Potsherds	38
Parts clay pots	42
Quartzite chips	2

Deer antler parts	4
Clay pipe fragments	3
Bar amulet, fragment	1
Banner stone fragments	3
Red slate fragment	1
Oyster shell	1
Clay concretion	1
Flattened stone	1
Gorget	1
Bone awls	9
Charred hickory nut.....	1
Pigment	1
Arrow points	64
Blades	14
Chipped implements	7
Drills	2
Net sinkers	7
Scrapers	4
Gorget fragments	2
Mortar	1
Axe, grooved	4
Hammer stones	5
Adz	1
Paint cups	2
Pestles	2
Celt	1
Gouge	1
Steatite	2

XIII

SCIENTIFIC PAPERS

THE PHILOSOPHY OF GEOLOGY AND THE ORDER OF THE STATE

*President's address before the Geological Society of America,
Albany, December 28, 1916*

BY JOHN M. CLARKE

Once each year we come together to renew our strength in unison, like Antaeus, by touching the earth.

I am conscious of taking some degree of liberty in departing from the usual form of this established function—the annual address. It would gratify me and might in some measure have diverted or persuaded you, if this occasion were given to the illumination of some specific technical theme. But the spirit of the hour seems to impel me rather to read from my experience and observation, or at least to portray as I see it, some part of the obligation of the state to our science and the responsibility of this science to the state.

The occasion is perhaps opportune, not so much in this place of meeting which happens to be the seat of government of but one of the many states here represented, and in the presence of members from two great federated governments; but essentially because, for the sake of all parties of interest, we must recognize more clearly the civic element in geological science and insist more pertinaciously on the immediate as well as the ultimate dependence of a state, if organized to endure, upon the demonstrated laws of this science.

I wish I might extend to my colleagues among the official geologists of many states an assurance that this address is to be devoted to some added demonstration of the obligation of the state to exploit to the utmost its geological resources, for the sake of the commercial interests of its community, but such public arguments are now superfluous. It is a primary impulse and an almost elemental instinct in the state to develop the commercial assets of its rocks. The appeal is so direct, so simple, so imperative that no state can afford to ignore a well-directed official effort to increase thus the general well-being and comfort of the commonwealth. The broad proposition is not debatable; the proposition in detail has always

been debatable and debated. Too often and too much in representative public opinion is the existence of the official geological organization justified by certain perfectly obvious considerations which subtend a large angle in the public consciousness. Gold and silver, iron and coal, petroleum and natural gas, and terms like these are made too often to set forth a reasonable vindication of official geology. But you and I may well insist that such factors as these reckoned in terms of the wealth of the state are not the justification of official geological research. We may as well draw back the veil — private enterprise will pretty effectively take care of such things as these without much help from us. Against such factors which we may term the obvious sources of wealth must be weighed the more recondite products which have seldom entered into the estimate of the law-making body or the public knowledge.

It is in these that many of our states are richest, not in those obvious factors. In a state like this, which I cite not for comparison but for illustration, the unexploited iron ore would seem to be well over a billion tons, while the actual value of the annual product of iron is not more than one-tenth that of the annual output from thirty or more different mineral products. And we can not even begin to estimate for our state the vast reserves in products undeveloped or conceive the now unknown applications to industry and the arts which our commonest geological compounds are competent to supply in response to the demands of the state.

I can see in such a state or in a union of states and governments such as ours, the demand for every human need, today actual and tomorrow possible, which is in any way dependent on the rocks of the earth, fully met here without reliance on any outside source. And it is of eminent importance that the state take counsel with itself to magnify such independence, at the sacrifice of its commercial ease, for dependence in commerce means no less than does dependence in the scheme of nature, that is, degeneration or stagnation.

I counsel therefore, you who are official servants of the state, to urge, within your power, upon the state this primary obligation: to take from no other what it can itself as well produce from its own stores. Insist, as the right is in you, that the state shall take account of the knowledge you possess for the full but conservative development of its own resources, and neglect no occasion to enforce the claims of the man who knows best, to precedence in these councils of the states.

I would not seem to profane my high office by stating in this presence the elemental conceptions of the science, but it is most imperative that I here, and you elsewhere, shall be lucid, exact and comprehensive in setting forth its claims, namely and briefly: that there is no substantial conception of property apart from the products of the rocks, the soils, the mines, the water, the air — and these in all their functions are geological factors; that there is no correct understanding of the meaning of human life, individually or in its complex community relations, if we stand with our backs to the great panorama of events which have builded the earth and the trains of life which have moved over it from the dawn of its history. It is most essential that every state should above all things comprehend these facts.

The current of my thoughts is toward the well-established principles of geology which have constituted the state; not the state as a geographical section of the earth, and not just now those principles which have laid its material foundations, builded its rocks, formed its veins and beds of ore, made its soil, established the sources of wealth as expressed in terms of human market; but unavoidably I turn to those principles which illumine the trail of humanity and have given it direction. My time has been long enough to ripen some of the green fruit of experience and enforce some deep-seated lessons. In the light of this experience and these associations there is no escape from the earnest conviction that the things of supremest value to mankind, the refined essences of the earth, lie in its records of the life which has gone before us. As the emergence of what we call the living, quoting Professor Chamberlin, is the transcendent event in the history of the earth, there is certainly no other fact in the presence of humanity so vital as that and the vast procession of the ages with the key it holds to our present state and future hopes. Need I say to this audience what I would wish to say to a wider: We are passing, we have stopped only to see the march of life and play our small part in the tremendous and endless pageant, happy indeed if, endowed with powers of divination, the rays of truth have dawned upon us from out of the past, to light the imagination on toward better things.

To what extent, then, are we fortified by the evidence of the past career of life in reading its oracle for our present guidance? This inquiry sets plainly before us, first, the paramount question as to the oft-alleged and too often magnified imperfections of the record of life upon the earth.

In many, probably in most, expositions of the science of geology and paleontology, prepared for the use of students and general readers, the so-called imperfections in the record of past life are brought out with a vivid intensity. These expositions are, I think, in large part due to a more or less unconsciously apologetic attitude on the part of the authors, as though they were in some way, being apostles of the science, likely to be held to account for any overstatement of its claims; and these attorneys in bankruptcy are not inaptly, to my mind, comparable to buyers of ancient but damaged rugs, torn, raveled, worn bare of their patterns: ostentatiously declaring their defects while overlooking the beauty, the symbolism, the perfection of the design seen clear through all the ravages made by the wear of time.

I find myself out of sympathy with such deprecating portraiture. Neither my experience nor my philosophy finds support for pessimistic conceptions of the ultimate hope of completing our tapestries from the patterns we know and the threads we are yet to pick up. For a few years, as we reckon human history, we have scratched with our hammers some surface exposures of the tablets of the law in parts of the earth most easily accessible to us, and the occasional explorer into remoter parts has gathered the life records in haphazard way, here a few pounds weight, there a few tons. Not one-fiftieth part of the exposed rocks of the earth has yet been closely scrutinized for these life records, and of the unexposed but known strata, practically none at all in the great total. This State of New York covers 47,000 square miles, two-thirds of which are underlaid by life records of the earth. This fossiliferous area is one eighteen-hundredth part of the land area of this globe, about one eleven-hundredth part of the exposed fossiliferous rocks. In this State the work of assembling the evidences of the life record has proceeded continuously in organized attack for eighty years. An eminent French geologist has intimated that there are few places of equal area in the world where the life record is so completely assembled — and yet every year brings new and necessary additions to our quiver. What shall we say of the other 1099 equal areas of fossiliferous rocks on the earth? Many of them have indeed been studied with precision but there remains and must remain for long years yet an overwhelming balance of the unknown. In the abundance and perfection of the life that is preserved in these rocks only the living seas themselves are comparable. I have estimated the number of individuals of a few of the species occurring in one in-

sulated mass of marine Devonian strata known as the Percé rock, a section which above the waterline represents a sea deposit 300 feet thick, 1300 feet long and about 250 feet wide; and the figures for these few species run into the hundreds of millions of individuals — and yet the rock is not richly fossiliferous, in the customary use of that expression.

It seems to be my experience, too, that the most closely studied formations have already yielded up a large percentage of their actual fauna. For some well-studied formations in limited areas the known fauna is, approximately speaking, a true and fairly full expression of the actual fauna. I can not of course pursue this matter here into its further details with its brilliant vistas already before us of learning the inchoate life of the primitive soils and first impounded waters, but I think I shall venture to enter the lists on call, to contend that for plant and animal life alike the records of the rocks where unaltered, are unimpeachable for adequate suggestiveness of the designs which the threads of life have woven. And when the imputation is too often made of imperfection through loss of anatomical detail, or the destruction of essential structures, compare by way of simple illustration compressed into the emergencies of this occasion the growth of knowledge of fossil anatomy within the fragment of the lifetime of one man. Fifty years ago all that was known of the ventral organization of the trilobite was a mere suggestion embedded in a nest of speculations; of its ontogeny a few discrete facts. So far has knowledge advanced that today we seem to know these animals in all their essential details and development; and if aught is left to become known of internal anatomy or ecology, the lessons of the past are the promise of the future. What was known of the Eurypterida fifty years ago was little but their outline and their grosser form. Today their ontogeny is understood almost from birth onward, their anatomy almost to ultimate details, their habits at least as well as those of vast numbers of living animals, their phylogeny as well as or better than the phylogeny of any living race subjected to this speculative treatment. Supplement these illustrations, which are nearest to me, with the scores of others known to you and with the tremendous strides made in this same period of time among the extinct vertebrates, and within the realm of lost floras where sheaves of knowledge have piled higher with every year.

These are the theses I should wish to nail on the doors of our temple:

Nature makes for the individual. This truth is registered on the tablets of the earth; it lies also in human observation and in human experience. Its recognition is of paramount importance; its acceptance sweeps away cobwebs of vagrant hypotheses which befog the pages of writers on political and social economics.

In the progressive line of development which in the present terminates in us, the procedure of nature has been one of only limited concern for the family and of tried out and abandoned experiment for social partnerships and the division of labor. To perfect the individual inconceivable safeguards have been thrown about him. The individual is creation's unit in terms of which all progress in life is to be reckoned. With unsparing hand she makes and wastes these units, both for her greater purposes and those which we may call her lesser ones. Units of purpose are wiped away to make place for units of other purpose. Yet the unit type remains; remains with its full seeding of possibilities, armored for its fight with double portions of food supply, of sense organs, of locomotive means, with an inexpressible superfluity of reproductive supply. Whether a given unit survive till its work be done or perish in the doing, it is the individual type that is at stake, it is against this individual type that all the powers outside it are imposing their obstacles.

This the geologist knows: There has been no cooperation in the historic development of the life in which we are directly concerned. We may not yet know the trend of many life lines for far in their history, but wherever such lines are best known, within the limitations of large natural divisions, those that run through from limit to limit and point the way both backward and ahead, and those other lines collateral to ours which have ended and determined fruitlessly -- these all can be conceived in no other way than variant expressions of the individual. And in the history of human life is it aught else than the individual that has stood for the progress of mankind? Was it the barons at Runnymede, was it some bill of rights, some declaration of independence, some joint action of human agencies that have been the crowns of our achievements? Or was it the Aristotle, the Plato, the Socrates, the Christ, a solitary Shakspeare, an incomparable Franklin, a rebellious Darwin, or the historic twenty individuals, who have stood for the progress of the race?

I say this only for the purpose of saying *per contra*, that the history of the excellent life (and by that I mean the line of life that is best perfecting its psychology), has shown the futility of attempts

at progress through any other agency than the independent individual. This is so important a conclusion to every state taking cognizance of its dependence on natural laws that it is highly essential to consider nature's own alternatives to such individualistic effort, her own experiments in trying out other modes of ascending heavenward. For "individual liberty," said President Butler speaking before the Constitutional Convention of this State, "is the cornerstone of the free state." That is the decree which is written in burning letters on every milepost of the course of life. "The perfection of the individual is the perfection of the race" says Professor Hoffman. "But," he adds, writing on the organization of the state, "the individual can have no rights or duties that conflict with the good of the whole"—a supplement for which it is exceedingly doubtful that any substantiation can be found in nature.

a It has been my environmental control to study and, I hope, to learn some of the lessons of life from their simplest and most easily legible expressions—a result that has come from living and laboring in a state built from the early waters with their undifferentiated expressions of life. The panorama of successive early worlds of life glows with the simple expressions of law which become more involved, supplemented and beclouded as the passing of the ages complicates the process of higher evolution, and produces expressions which, in terms of existing life alone, would be difficultly intelligible. The study of the meaning of existing life without the light of its vast history leads nowhere.

It is safe to say, I think, that living beings at the start, animated nature whatever its composition, had an equal chance for progress and improvement. How soon that chance became forfeit we can not say, but it is obvious that life was not long begun and its greater stocks established when their courses throughout existence were set and determined. Nothing is more obvious in chronology than nature's deliberate failures, nothing more clear in paleontology than her set purposes.

The vast subkingdom of the Mollusca started well with bodily independence, fully equipped with locomotive powers, an excellent innervation, but they sold their birthright for ease and content. They soon became dependent upon the movements of the waters and waited for the waves to bring them food. Compact in their protection and adaptation, these types of life have come crowding down through the ages in inexpressible variety. They and their allied phyla in the great subkingdom to which they belong have, it

would seem, struggled now and again to regain their primitive independence and maintain it, but the early condemnation of the law has overawed them and out of them all has come, and can come nothing better. They had their chance. That chance was missed; for untold millions of years they have failed to improve. They still cumber the earth and teach the lesson of an incurable heritage. You who are students of ancient life know how great is the multitude of lessons like this.

None of the observations of the competent have afforded any evidence that the lines of development through such groups of lowly animals have led to anything of promise or of excellence. The ages have rolled away and left them still with us, progressed, arrested or degenerate within their own narrow limitations, as the case may be. There is no evidence to indicate that these great groups from which nothing can be expected were deprived of their equality of opportunity as contrasted with the other great subkingdoms of the annelids and the articulates from one or the other of which, or from one and the other in succession, our own line has been derived.

The lesson then is this, that dependent conditions of life, however we may see them, throughout untamed nature or in our own communities, are not primitive, are not in the essence of things, but they are set back so far in the history of life that they are now or seem to be unavoidable and unconquerable.

These evidences I have discussed before this society on previous occasions. The field of observation and of inference as well, is greatly to be enlarged and well justifies the appeals that have been made on its behalf, but so much at least is indicated: that here and in analogous cases parasitic existence in whatever group in nature, and with whatever expression in the natural assemblage or the community group, involves the essential abandonment of normal direct upright living and the benefactors thereby are types of life which nature has cast out and aside as hopeless.

It is probably yet to be determined, at least there is no record I can find, that even in the passing of the ages nature has ever set up again upon its feet an organism or group of organisms once fallen into this dejected mode of life.

It is well the state should recognize this harsh truth which is a law. With a police power guided by intelligence and sympathy, some of the harshness in this inevitable human condition may be ameliorated, but the paleontologist looking at the record of life on the earth says to this state: Be intelligently guided in the treat-

ment of hereditary community parasites, defectives, congenital or confirmed misdemeanants, whatever the form of degeneration may be, by recognition of the presumption that in so far as they can not be physiologically corrected, they are abandoned types in which there lies little hope of repair. I can state this conclusion only thus succinctly without here attempting to present or argue its many ramifications.

b Soon after the great outburst of articulate life in the Cambrian, wherein, so far as our present knowledge permits, we find the lines along which have come the complicated expressions of today; somewhere in there, we may not say securely now, branched out the great phylum which led into the world of insects. We are wont to say that the first whirr of insect wings was made by the dragon flies and great cockroaches of the Devonian forests — an admission which of course implies that long earlier ages saw the differentiation of this type of life. At all events the six-legged type of articulates adapted to life in the water and air, full of vivacity and agility, with full independence, equipped with all potentialities that come from abundant innervation — this type, this six-legged articulate expression of existence, the insecta, started reasonably early on its career. It is my desire to note only in passing that, however close and direct may be the derivation of the vertebrate type from the primitive articulate stock, we have no inheritance from and hence only a collateral interest in this six-legged type of articulate life. Yet the outcome of development along this line has led to most extraordinary displays of morphological and psychic differentiation. A distinguished naturalist has said that the brain of an ant is the most marvelous speck of matter in existence. I hardly need, before this audience, to recall the exquisite and minute specialization in morphology, physiological function, performance and, I should say, conscious or at least psychic behavior among the most advanced attainments of development in the six-legged articulates, the social insects. The ant colony is the ideal of differentiation of function. Its members are by birth and inheritance, food and training, destined to certain specific duties in the colony. Armies are marshalled, wars are waged, the wounded nursed, the captives are trained for their duties, gardens are planted and crops are harvested; the stock is fed and food is stored, and a score of marvelous concerted doings which amaze us by the perfection of their totality, which is — the welfare of the community. Here the individual is actually constructed nervously and physically, anatomically and physio-

logically for the niche in the community which he is destined to fill. No human community where cooperative efficiency has submerged the individual and has been the objective and the attainment, no such human community has ever yet reached such an ideal of joint effectiveness as has a colony of ants. The ants are nature's great triumph, her highest performance in communistic effort and in cooperative achievement. And what has come or can come of development along this line?

Let us look back a little into the antecedents of the ants. Says Professor Wheeler, "So many genera and species of these insects appear full fledged in the early Tertiary we are compelled to believe that they must have existed in the Trias or even in the Lias, but belonged to so few genera and species, or lived in such small communities that they left no remains." This distinguished student cites 276 Tertiary species as indicative of their sudden outburst, or perhaps it would be safer to say the development of better modes for their preservation, and he has further stated that there is no reliable observation to prove that polymorphism was existent among the earliest ants of this long period. This differentiation does, however, show itself in the fossil ants of the Quaternary.

This paramount attainment of intellectual activity in the line of insect development, in the line of the six-legged type, would seem thus to have been accomplished largely through the same period of time when the human line was perfecting its mentality. The psychology of the two ultimate results is separated by processes and directions of development as wide apart as the poles. Neither is to be expressed, perhaps, in terms of the other. The results too are wide asunder—one a deadly communism, a moribund partition of labor, a lethal socialism; the other an active, progressive and fertile individualism. For the former the student of nature's history sees no outcome. These too are nature's experiments. The six-legged type with all its purposes in its highest expression lies prostrate on the ground at our feet, it and its achievements have risen to nothing higher than an ant hill, its communistic relations and subservience are entirely apart from the true genius of humanity. Socialism and communism have been tried out and found wanting, and nature holds conspicuously before the eye of the state the warning that they have nothing either for the growth of the spirit or the progress of the intellect.

c I regard as peculiarly a doctrine of paleontology, one whose demonstration or confutation would be hopeless in the hands of

the biologist, that of palingenesis, or recapitulation, or in other words the broad and familiar statement of the fact that each individual carries in himself and his development history, the history of the race to which he belongs, however accelerated or however retarded it may be. I am trenching familiar ground, but it is because I would remind this audience that not the mere existence but the panorama of life is essential to this conception and that the law remains only an assumption of probability as long as its manifestations are pursued only among creatures of high specialization. In our bodies politic the more complicated our existence becomes the more like a tangled web of ordinances become our statutes. Forty-five thousand new statutes it is said have been enacted in the last five years in these states for some of us to trip and fall over, and just as it is difficult to pick our way through this tangle of expeditious legislation, so it is likewise difficult to read in highly specialized organisms the leading of this great governing principle of biogenesis. If we do trip and fall among the entanglements of the statutes, the difficult mechanism of our present community life, let us remember that also back even of the bewildering, confusing, interlocking webs of the physiological mechanism of evolution lies, outspoken and luminant, the simpler expressions of the basic law on which rests the whole superstructure of evolution whether of the individual or of the state.

d It is well for us, well for the state, that we read aright the teaching of the greater past upon the doctrine of majority control, for whatever enduring virtue it has takes its roots in these past procedures of life when laying the foundations of its phyla. Over and over again the dominant race has started on its career as an insignificant minority struggling for its existence against an overburden of mechanical and vital obstacles, armed only with specific virtues which have little by little fought their way into the foreground, and by so doing consummated their upward purpose. If I refer to the geological history of the phylum to which we belong, the Mammalia, it may stand for the oft-repeated procedure which has in various forms come under the notice of every paleontologist. The Prototheria, or the first of all mammals, appeared upon the scene in the Jurassic, diminutive, mouselike creatures even yet retaining from reptilian ancestors the function of ovulation, possibly having already developed a marsupial pouch for their nurslings, insectivorous in dentition, creeping inconspicuously through sheltered places of the forests or among the crevices of the earth,

their minute but agile brains by which they were steering their course, tremendously exceeding in proportion the brains of the giant reptiles whose variant forms constituted the majority and made them masters of earth and air and sea—whose gigantic physique and fleshly lusts had outstripped the early promise of their cephalic ganglia and left them hopelessly decephalized. Insignificant in size and number, but equipped with the vigor of phyletic youth, agile adaptability, locomotive independence left unimpaired through excessive food supply, with such equipment, good balance between cephalic and motor nerve centers, these inconspicuous and feeble folk started on their career of triumph over an overwhelming majority. Time passed and the deed was done. The agile-witted founders of the race had spread abroad through the earth. They grew vast in number and variety, adapted to all media of earth and air and sea. To them at last came the temptations of the flesh pots; they grew great in bulk, slow in body, weaker in locomotion and feebler in proportion. They too had met their impasse and there was nothing beyond. The majority had arrived, but the majority had fed itself fat on the spoils of the conquest and was moribund. Once more out of this majority arose the protest of the minority and again the keener witted, better cephalized, unimpaired, but obscure and diminutive minority, strong always at the head, emerged from the welter of self-indulgence to save the race. Robbed of luxuriant food supply by a mantle of ice, its vitality quickened and stimulated by the invigorating cold, imperiously compelled by a world chill which hung upon the earth unknown years to purge itself of indirection and seek the straightest way to physical salvation through the practice of simple virtues; from out of such conditions came the human stock.

If we do not recognize fully the fact that a majority control in our governments is purely a matter of expediency in the handling of civic affairs, let us remind ourselves of it on this occasion. We need only the reminder, for however often the man in the ward and the voter at the polls conceive that a majority is the paramount issue at stake, it is too often forgotten that the majority is purely numerical while wisdom and truth may rest with the minority. Amidst the inevitable expediciencies of government this is its salvation—that the minority, if clear and strong at the head, like an antecedent river, will cut down mountains of opposition.

"The triumphs of liberty have been due to minorities" said Lord Acton. "The rule of the tyrant is tyranny whether he have

one head or many. The principle of absolute majority rule is as profoundly immoral and as profoundly undemocratic as is the principle of the divine right of kings. Majority rule is a practical device for the working of free institutions and not a principle without limits or bounds upon which free institutions may be based."

This is the teaching of our science; the ephemeral worth of majority control is always obvious; the voice of the people is not the voice of God.

e We have come to a point in our researches where observation and inference teach us that life originated in unicellular microbic forms under conditions which have been indirectly indicated by the Chamberlins, father and son, as governed by and intimately associated with a conjunction of soil and moisture, with obstructed air, and probably without direct exposure to the actinic action of the sunlight. There has already been interesting and substantial confirmation of the presence of actual bacteria in the most ancient rocks of continental origin antedating the Cambrian, and many well-demonstrated expressions. The discovery of fossil bacteria is to be accredited to several students, Van Ingen among others, but their existence in this age preceding the primordial outburst of life, in times when by every line of sequential reasoning they should exist, this important determination is among the brilliant results of Walcott's researches.

So now every legitimate evidence of fact and deduction points to the origin of microbic unicellular life in the moist, subaerated soil away from the direct sun; and the soils of today are alive — a mighty host — with such microbic creations existing under paraneurobic conditions. This army, we are coming to understand, is endowed with specialized functions; and if this statement is, and is to remain, approximately correct, then the acquisition of such special functions speaks of a long past with its gradual and cumulative inheritance. It still remains to be demonstrated that the cycle of life is renewing itself from day to day by the continued transmutation of the inorganic to the organic, however such a possibility may lie in the lap of logic. But it is well for us to realize that this microbic life which in the passage of time has become adapted to such special functions that we recognize among them germs of disease as well as of benignancy, has the historic impress of hostility to the direct rays of the sun. Microbic disease is disease only from the human standpoint, from the point of view of the host of the disease-causing parasite. For the germ — the microbic parasite

itself—it is normal living. I think we may well urge upon the attention of pathogenists the importance of estimating the historic impress which is, in all disease-making bacteria, the natural primitive and inherited hostility to the sunlight. In the adjustments and readjustments of these parasites to special hosts and specific toxic processes some may have overcome in a measure this natural antagonism, but for the most their work is in the dark. The marvelous results which have been attained in the treatment of tetanus during the present war, by simple and constant exposure to the sunlight, encourages us to believe that in similar pathology a like treatment would be historically and logically correct.

Fifty years ago when President Andrew D. White published his "Warfare of Science and Religion," he said, "A Truth written upon the human heart today in its full play of emotions or passions can not be at any real variance with the truth written upon a fossil whose poor life ebbed forth millions of years ago." These fifty years since have enabled us to say with equal security that the record written on the fossil is the candle by which we must read the fate of the community, the passions and emotions of the human heart.

We have been shocked into a consciousness that not all the virtues abide in us. You may recall the ancient days of Rome when the people annually gathered to pay an offering of oil and wine, of milk and violets to the spirits of their ancestors, from the study of whose examples they gained for themselves and inculcated in others a respect for the virtuous past. So we say our *aves* to the great past out of which we and all our guiding principles in individual life, in the community, in the state, have come.

Our broader vision which must be the bloom of our intense specialization is like the dream of the patriarch who, resting his head on a pillow of stone, saw a ladder reaching from this earth to heaven and beheld the angels of God ascending and descending on it.

THE PALEONTOLOGY OF ARRESTED EVOLUTION

BY RUDOLF RUEDEMANN

Address by the President of The Paleontological Society, Albany, December 1916

When last year your society honored me in electing me your president, it was my first desire to present in my address a general survey of the work in which I have been most interested, namely, the analysis of the faunas of the graptolite shales and their correlation. Fear that this theme might not be of sufficiently general interest, and still more the discovery of new facts in the last two years, calling for further investigations of the Ordovician shales, have influenced me to select another problem for presentation in which I have also been interested for some years. This is the Paleontology of Arrested Evolution, as seen in the persistent types and relicts. Unfortunately, this problem, also, as here presented, is still far from being solved, and I have to beg your indulgence for obvious shortcomings.

INTRODUCTION

The student of fossil faunas, both for stratigraphic and biologic ends, can not fail to be struck by the remarkable differences in the ranges of the various species, genera, families and higher groups. As a rule, the broad stream of organisms that passes our view in geologic history changes quite regularly from formation to formation, but there are certain species and genera which reappear again and again without any or with but slight variation, often in totally different faunal associations. These types which thus remain unchanged throughout a number of formations have been designated as *persistent* or *conservative types*, in contradistinction to the *variable types*. As pointed out by Osborn (*The Age of Mammals*, p. 7), it was early observed by Huxley,¹ Cope and others, that Cuvier's broad belief in a universal law of perfection was errone-

¹ Huxley, in his anniversary address to the Geological Society of 1862 on "Geological Contemporaneity and Persistent Types of Life" (reprinted in "Lay Sermons, Addresses and Reviews," 1906, p. 176) has, in a general way, established the existence of persistent types of structure, and from a general survey of the development of the organic classes reached the conclusion that the common doctrines of progressive modification which suppose that modification to have taken place by a *necessary progress* from more or less embryonic forms, or from more or less generalized types within the limits of the period represented by the fossiliferous rocks, are negated by the evidence of the persistent types, for it either shows no evidence of any such modification, or demonstrates it to have been very slight.

Our purpose and scope of investigation in the present paper is different from that pursued by Huxley.

eous, and these authors began to perceive the difference between *persistent primitive types* (Huxley) and *progressive* or *advancing types*.

The causes underlying the variation of species have been, since Darwin's time, and are still the storm center of discussions of evolution; the negative side of the question or the continuous failure to vary has been thought hardly worthy of notice, partly because its frequency impresses itself principally upon the paleontologist only, and partly because it seems to promise little of importance to that discussion. Various facts, however, have come to our notice which bear on this problem and appear to invite a brief investigation of the causes of persistence, principally as it appears among invertebrate fossils.

Persistence of types, generic and specific, presupposes the avoidance of two antithetic causes of extinction; to be persistent a type must not be variable, for if it develops into another type it becomes extinct as the former type and, though living in its descendants, it is *relatively extinct*; further, it must not become *absolutely extinct* through death of the race. Variability is the general means to adaptation and progressive development, and so persistent types must, generally speaking, be in the peculiar position of being not so highly vitalized or *alive* as the developing and climacteric forms, and yet still too vigorous to become extinct or permit the death of the race.

It seems to us that the generic units permit the clearest survey of the persistence of types. We shall therefore make this unit the principal subject of our investigation.

The ranges of the persistent genera, as here given, are extracted from Zittel-Eastman's *Textbook of Paleontology* (1913); and I have here defined as persistent all genera which pass through more than two periods.

Tables of Persistent Types

The most striking cases of persistence are among the *Foraminifera*, as follows:

Ordovician — Recent.....	Saccamina
Silurian — Recent	Lagena, Nodosaria
Carboniferous — Recent.....	Ammodiscus, Dentalina, Endothyra, Lituola, Rheophax, Textularia, Valvulina, Ammobaculites
Carboniferous — Tertiary	Nummulites
Triassic — Recent.....	Bulimina, Cristellaria, Frondicularia, Glandulina, Globigerina, Lingulina, Marginulina, Orbulina, Polymorphina, Vaginulina, Miliola, Placopsilina, Trochamminoides

Jurassic — Recent.....	Astrorhiza, Rhabdammina, Marsipella, Bathysiphon, Rhizammina, Planorbulina, Pulvinulina, Rotalia, Polystomella, Cornu- spira, Nubecularia, Ophththalmidium
Cretaceous — Recent.....	Calcarina, Discorquina, Operculina, Sphaeroid- ina, Bolivina, Ellipsoidina, Chilostomella, Allomorphina, Dimorphina, Hauerina, Alveolina

Not only the genera possess this remarkable persistence but also many species persist, according to Parker, Jones, Brady, Bagge and others, throughout a number of formations (see p. 126). In general, the persistence of the Foraminifera surpasses that of all other orders which are known in fossil condition. The Radiolarians were probably as persistent in their genera but the group is still very imperfectly known in its fossil representatives, especially the Paleozoic. Their minute and delicate skeletons are, however, known to have been as abundant and diversified in the past ages as at present.

The *sponges*, contrary to expectation, furnish but very few persistent fossil types:

Cambrian — Carboniferous ...	Hyalostelia
Devonian — Cretaceous	Peronidella
Carboniferous — Jurassic	Cnemidiastrum (Hinde)
Carboniferous — Cretaceous ..	Doryderma (Hinde)
Triassic — Cretaceous	Corynella, Raphidonema, Sestrostomella
Jurassic — Tertiary	Craticularia
Cretaceous — Recent.....	Cystispongia

A great number are found among the *corals*:

Ordovician — Devonian.....	Anisophyllum, Aulacophyllum, Columnaria, Halysites, Heliolites, Plasmopora
Ordovician — Carboniferous ..	Amplexus, Aulopora, Cyathophyllum, Em- monsia, Favosites, Petraia
Silurian — Carboniferous	Clisiophyllum, Strephodes, Syringopora, Zaphrentis
Carboniferous — Jurassic	Chaetetes
Triassic — Cretaceous	Isastraea, Styliina
Triassic — Tertiary	Astrocoenia, Astraeomorpha, Calamophyllia, Dimorphastraea, Montlivaultia, Phyllo- coenia, Thecosmilia, Dimorpharaea
Triassic — Recent	Stephanocoenia
Jurassic — Tertiary	Comoseris, Cyclolites, Leptoria
Jurassic — Recent	Cladocora, Favia, Goniastrea, Orbicella, Stylophora, Trochocyathus, Theocyathus
Cretaceous — Recent	Caryophyllia, Ceratotrochus, Coelosmilia, Diploria, Lophosmilia, Sphenotrochus, Goniastrea, Porites, Turbinaria, Heliopora

Some remarkable ranges are cited among the *Bryozoa*, namely:

Ordovician — Devonian	.....	Corynotrypa, Ceramopora, Discotrypa, Eridotrypa, Hallopora, Monotrypa, Monotrypella, Pseudohornera, Petalotrypa
Ordovician — Carboniferous	..	Lioclema, Rhopalonaria, Vinella, Heteronema
Ordovician — Permian	.....	Rhombopora
Ordovician — Recent!	.....	<i>Berenicea</i> (culminates Jur.-Cret.) <i>Stomatopora</i> , <i>Proboscina</i>
Silurian — Carboniferous	....	Allonema, Ascodictyon, Chilotrypa, Eridopora, Hemitrypa, Meekopora, Acanthoclema
Silurian — Permian	.....	Fistulipora, Polypora, Thamnisus, Batostomella, Cystodictya, Dichotrypa, Coscinium, Fenestella, Pinnatopora, Phyllopora
Triassic — Recent	.....	Ceripora
Jurassic — Tertiary	.....	Diastopora, Fasciculipora, Theonoe
Jurassic — Recent	.....	Entalophora, Heteropora, Idmonea, Lichenopora, Spiropora, Crisina, Membranipora, Onychocella
Cretaceous — Recent	.....	Crisia, Filisparsa, Phalangella, Actinopora, Eucratea, Cyrtopora, Reticulipora, Discocavea, Hornera, Cribulina, Lepralia, Lunulites, Floridina, Smittipora, Micropora, Membraniporella, Porina, Selenaria, Schizoporella, Smittina, Mucronella, Porella

Among the *Brachiopoda* we find:

Ordovician — Devonian	.....	Dalmanella, Glassia, Scenidium, Atrypa, Atrypina, Schizocrania
Ordovician — Carboniferous	..	Leptaena, Pholidops, Rhipidomella
Ordovician — Permian	.....	Chonetes
Ordovician — Cretaceous	....	Orbiculoidea
Ordovician — Recent	.....	Crania, Lingula (two maxima of Crania, one in Ordovician, another in Cretaceous)
Silurian — Carboniferous	....	Schizophoria, Schuchertella, Camarotoechia, Wilsonia, Cyrtina, Nucleospira, Spirifer
Devonian — Permian	.....	Dielasma, Strophalosia, Seminula
Carboniferous — Jurassic	....	Spiriferina
Triassic — Cretaceous	.....	Aulacothyris
Jurassic — Recent	.....	Acanthothyris, Lacazella, Magellania, Megathyris, Muchfeldtia, Terebratella, Terebratulina
Cretaceous — Recent	.....	Agulhasia, Argyrotheca

The persistent types among the *Pelecypoda* are:

Ordovician — Devonian	.....	Cleidophorus
Ordovician — Carboniferous	..	Pterinea
Silurian — Carboniferous	....	Aviculopecten, Cardiomorpha
Silurian — Jurassic	.....	Posidonomya
Silurian — Recent!	.....	<i>Leda</i> , <i>Nucula</i> (over 200 fossil and as many recent species)

Devonian — Triassic	Solenopsis, Pleurophorus
Devonian — Cretaceous.....	Pseudomonotis
Devonian — Tertiary	Parallelodon (maximum in Coal measures)
Devonian — Recent	<i>Modiolus</i> , <i>Pteria</i> ¹
Carboniferous — Cretaceous.	Entolium, Myoconcha
Carboniferous — Recent	Atrina, Lima (subgenera: subgenus Limaea: Jurassic-Recent), Ostrea, Solemya, Lithophagus (Lithodomus)
Triassic — Cretaceous	Homomya, Opis, Pleuromya, Tancredia, Unicardium
Triassic — Tertiary	Gervillia
Triassic — Recent	Alectryonia, Cardita, Cardium (subgenera), Chlamys, Corbula, Gastrochaena, Hinnites, Limopsis, Mytilus, Pedalion (Perna auct.), Plicatula, Thracia, Lucina
Jurassic — Tertiary	Anisocardia, Gryphaea
Jurassic — Recent	Amusium, Anatina, Anomia, Arctica, Camp- tonectes, Corbis, Cucullaea, Cuspidaria, Cyrena, Cyrtopinna, Isocardia, Phola- domya, Pholas, Pinna, Spondylus, Tellina, Teredo, Trapezium, Venus, Trigonia
Cretaceous — Recent	Acila, Acharax, Yoldia, Batissa, Chama, Clavagella, Crassatellites, Dosinia, Gly- cimeris, Panope, Pecten, Pseudamusium, Sphaerium, Spisula, Venericardia, Ungulina, Thyasira, Paphia

Among the *Scaphopoda* the persistent types are represented by:

Silurian (?) — Recent	Laevidentalium
Carboniferous — Triassic	Plagioglypta
Cretaceous — Recent	Antalis, Fustiaria, Cadulus

The *Gastropoda* furnish the following persistent genera:

Cambrian — Silurian	Trochonema
Cambrian — Carboniferous ..	Subulites
Cambrian — Triassic	Murchisonia
Cambrian — <i>Recent!</i>	Capulus (see p. 116)
Ordovician — Devonian	Cyclonema, Eunema, Holoepa, Lophospira, Oxydiscus, Sinuites
Ordovician — Carboniferous ..	Omphalotrochus
Silurian — Carboniferous	Diaphorostoma, Lepetopsis, Metoptoma, Holo- pella, Natiria, Orthonychia, Platyceras, Platyschisma
Silurian — Permian	Bellerophon
Silurian — Triassic	Euomphalus, Loxonema, Macrocheilus, Scalites (?)
Silurian — Triassic	Straparollus

¹ Several subgenera, among them *Meleagrina*, Jurassic-Recent; *Oxytoma*, Triassic-Cretaceous.

- Silurian — *Recent!* *Acmaea*, *Eetrochus*, *Patella*, *Pleurotomaria*
(subgenera, see p. 116), *Trochus* (sub-
genera), *Turbo* (?)
- Devonian — Triassic *Naticopsis*
- Devonian — Cretaceous *Zygopleura*
- Carboniferous — Jurassic *Bourgetia*
- Carboniferous (?) — Tertiary. *Pseudomelania*
- Carboniferous — *Recent!* *Actaeonina*, *Emargiaula*, *Fissuridea* (?), (*Fis-
surella* auct.), *Vermicularia* (*Vermetus*
auct.), (?) (Subgenera)
- Triassic — Cretaceous *Amberleya*, *Cylindrites*, *Fibula*
- Triassic — Tertiary *Discohelix*
- Triassic — *Recent!* *Astralium* (subgenera), *Calliostoma*, *Cylichna*,
Delphinula, *Eulima*, *Epitomium* (sub-
genera), *Monodonta*, *Natica* (subgenera),
Nerita (?), *Neritopsis*, *Niso*, *Turritella*
(subgenera)
- Jurassic — Tertiary *Pileolus*, *Tornatella*
- Jurassic — Recent *Aporrhais* (subgenera), *Bullaria* (?), *Bullina*,
Cerithium (subgenera), *Cypraea*, *Etallonia*,
Fusus, *Hydatina*, *Liotia*, *Littorina*, *Mathilda*,
Melania, *Rimula*, *Rissoa*, *Rissoina*, *Scurria*,
Solarium
- Cretaceous — Recent *Acteon*, *Ancilla*, *Bithinia*, *Calyptrea*, *Chry-
sodomus*, *Clavatulula* (subgenera), *Cominella*,
Conus (subgenera), *Crepidula*, *Diastoma*,
Erato, *Fasciolaria*, *Galeodea*, *Hipponyx*,
Hydrobia, *Latirus*, *Megalomastoma*, *Melan-
opsis*, *Murex* (subgenera), *Nassa*, *Nyctilo-
chus* (*Tritonium*), *Oliva*, *Phasianella*,
Philine, *Pleurocera*, *Pseudoliva*, *Potamides*
(subgenera), *Pyramidella*, *Pyrula*, *Rapana*,
Rimella, *Ringicula*, *Scaphander*, *Siliquaria*,
Strombus, *Tonna*, *Tudicula*, *Turricula*, *Turris*
(*Pleurotoma*) (subgenera), *Typhis*, *Vivi-
para* (subgenera), *Xenophora*

The *Pulmonata* contain as persistent genera:

- Jurassic — Recent *Auricula*, *Carychium*, *Lymnaea*, *Planorbis*,
Physa
- Cretaceous — Recent *Glandina*, *Megaspira*

There are also persistent types among the *Pteropoda*, namely:

- Cretaceous — Recent *Clio* (subgenera), *Vaginella*

Conularia is recorded as ranging from Ordovician-Jurassic;
Hyolithes from Cambrian to Permian.

The *Cephalopoda* furnish the following persistent genera, all
among the Nautiloidea:

- Ordovician — Devonian *Clinoceras*, *Cyclostomiceras*, *Zitteloceras*
- Ordovician — Carboniferous .. *Actinoceras* (subgenera), *Geisonoceras*, *Loxo-
ceras*, *Poterioceras*, *Spyroceras*

Ordovician — Permian Cycloceras
 Silurian — Carboniferous Kionoceras, Protobactrites, Thoracoceras

There are no persistent genera among the *Ammonoidea* and *Dibranchiata*.

The *Trilobites* contain a few persistent genera, namely:

Ordovician — Devonian Goldius (Bronteus), Calymmene, Conolichas,
 Cyphaspis, Hoploichas

Ordovician — Carboniferous .. Proetus

The *Branchiopoda* contain:

Devonian — Pleistocene Estheria

Triassic — Recent Apus

The *Ostracoda* have the following persistent genera:

Ordovician — Devonian Beyrichia, Primitiella

Ordovician — Carboniferous .. Aechmina, Bollia, Entomis, Leperditia,
 Ulrichia

Ordovician — Permian Primitia

Ordovician — Recent! Bairdia (maximum in Carboniferous), Bythocypris, Cypridina, Cytherella, Macrocypris

Silurian — Recent! Pontocypris

Permian — Recent! Cythere

Jurassic — Recent Cytheridea

Cretaceous — Recent Cythereis, Cytherideis

The *Cirripedia* contain the following persistent genera:

Cambrian (?) — Devonian Turrilepas

Ordovician — Devonian Lepidocoleus

Cretaceous — Recent Chthamalus, Scalpellum

The *Malacostraca* contain a small number of persistent types, namely:

Triassic — Cretaceous Glyphaea, Lithogaster

Jurassic — Recent Callianassa

Cretaceous — Recent Astacus (?), Homarus (?), Nephrops (?),
 Panopeus

There are no arachnid (save the extinct *Merostomata* given below), myriapod, or insect genera recorded as passing through two or more formations. Among the *Merostomata* are:

Ordovician — Devonian Pterygotus

Ordovician — Permian Eurypterus

Triassic — Recent Limulus

Among the *fishes* the following Selachians are persistent:

Triassic — Cretaceous Acrodus

Jurassic — Recent Cestracion, Hybodus, Pristiurus, Rhinobates

Cretaceous — Recent Acanthias, Callorhynchus, Carcharodon, Centrophorus, Lamna, Pristiophorus, Odontaspis, Raja, Scapanorhynchus, Scyllium, Squatina

The *Dipnoi* contain:

Triassic — Recent *Ceratodus*

The *Teleostei*:

Cretaceous — Recent *Diplomystus* (in rivers of New South Wales and Chili)

There are no persistent genera among the *batrachians*, and none among the *reptiles* save the turtle *Chelone* which ranges from Cretaceous — Recent.

No persistent genera, as here defined, are found among the *birds* and *mammals*.

In the following table we have compared the number of persistent genera of each group cited in Zittel's textbook with the total number of genera cited there, adding the percentage of persistent genera:

			NUMBER OF PERSISTENT GENERA		TOTAL NUMBER OF GENERA CITED		PERCENTAGE		AVERAGE		
			A Zittel- East- man 1896.	B Zittel- East- man 1913	A	B	A	B	A	B	
Foraminifera.....			29	48	77	86	38	56	38	56	
Sponges.....			7	9	90	149	8	6	8	6	
Corals.....			42	46	242	237	17	15	17	15	
Echino- derma	{	Crinoidea.....	10	5	169	277	6	2			
		Cystoidea.....	1		38	96	3				
		Blastoidea.....	2	1	23	23	10	4	6.5	4.5	
		Ophiuroidea.....			17	25					
		Asteroidea.....	5	5	32	43	16	11			
		Echinoidea.....	8	19	194	191	4	10			
Bryozoa.....			49	68	225	306	21	22	15	15	
Brachiopoda.....			29	33	298	384	10	9			
Mollusca	{	Pelecypoda.....	71	78	452	446	15	16			
		Scaphopoda.....	3	5	14	18	21	27			
		Gastropoda.....	108	126	376	420	29	30			
		Pteropoda.....	5	5	17	17	29	29	14	15	
		Pulmonata.....	8	7	67	65	12	11			
		Cephalopoda {	Nautiloidea.....	12	12	170	170	7	7		
			Ammonoidea.....			455	455				
Crust- acea	{	Trilobita.....	7	6	53	131	13	4.5			
		Ostracoda.....	16	18	45	68	35	26.5			
		Cirripedia.....	5	4	20	20	25	20	20	14	
		Malacostraca.....	9	7	147	134	6	4.5			
Arachnida ¹			3	3	42	66	7	4.5			
Selachii.....			16		168			9.5			
Dipnoi.....			1								
Teleostei.....			1								
Reptilia.....			1								

¹ Including *Merostomata*.

It is obvious that some of these figures are misleading in some regards. They give a fair representation of the percentages in the entirely or nearly extinct classes, while in those which are now

culminating or just beyond their climacteric period, the percentage is too high, the great number of recent genera not being taken into account.

Immortal Types

Of greatest interest are the types which range from the Paleozoic to the present time. These, one might well term *immortal types*. They are principally found among the Foraminifera (11 genera and 13 from the Triassic-Recent); Pelecypoda (9 genera); Gastropoda (13 genera and 12 genera from Triassic-Recent); and Ostracoda (7 genera). It is, however, to be considered that at least some of these extreme ranges may result from as yet incomplete knowledge of the forms, especially among the Pelecypoda and Gastropoda. Thus, of the two immortal bryozoans, *Berenicea* and *Stomatopora*, the latter has lately been shown by Bassler to differ from the Paleozoic forms hitherto referred to them, and in the case of the gastropods, Perner restricts *Pleurotomaria* to the Mesozoic genera, separates *Platyceras* from *Capulus* of Tertiary and recent age, but points to the great resemblance of the Paleozoic forms to this latter genus.¹

Considering, however, the close study that has already been given to the lower invertebrates both here and abroad, it does not seem to us probable that these figures will be greatly reduced. On the contrary, a comparison of the figures given in the preceding table and taken from the editions of Zittel-Eastman of 1896 and 1913 even brings out a considerable increase in the more important groups, namely, in the Foraminifera from 29 to 48, the Corals from 42 to 46, the Bryozoa from 49 to 68, the Pelecypoda from 71 to 78, the Gastropoda from 108 to 126, all in the short period of seven years, as the result of the discovery of longer ranges of forms.

But even if it be conceded for the sake of argument that the majority of these persistent genera may, on further study, be found to be still divisible into successive groups and that the absolute persistence is hence merely a deception due either to lack of knowledge or to extremely slow but still perceptible variation and development, then the fact of their extremely slight change and relative stability as contrasted with the rapid development of the

¹ He cites as gastropod genera remarkable for their longevity: *Carinaropsis*, *Clisospira*, *Euryzone*, *Hercynella*, *Palaeacmaea*, *Loxonema*, *Platystoma*, *Turbonitella* and *Eotomaria*. The four genera *Bembexia*, *Calloconus*, *Mourlonia* and *Trochonema* are peculiar for their manner of reappearing after long periods of absence (*Geol. Mag.*, Aug. 1911, p. 374.)

great mass of the organic types, would still remain true and invite investigation of its underlying causes.

General Inferences from Tables

From a general survey of the percentages of persistent types of the classes and of their subdivisions, we may draw the following inferences:

1 *The lower classes tend in general to have more persistent types than the higher.* This is exemplified by the higher percentages of the Foraminifera, Corals, Molluscoidea and Mollusca in contrast with those of the Arthropoda and Vertebrata. And the extreme cases of longevity, the immortal types, occur only among the lower classes. Most of them are found among the Foraminifera; then follow the Molluscoidea and Mollusca, and a few are also met among the Crustaceans, but none among the other arthropods and the vertebrates.

2 *Within each order and class, again the lower subclasses tend to furnish the greater percentage of persistent forms.* This is best exemplified by the Pelecypoda (16 per cent) and Gastropoda (30 per cent) in contrast with the Cephalopoda (2 per cent), and within the latter by the fact that the Nautiloidea contain all the persistent types and the Ammonoidea and Dibranchiata none. Also within the Crustacea, the Ostracoda (26.5 per cent) and Cirripedia (20 per cent) contrast with the Malacostraca (4.5 per cent). Among the vertebrates the primitive Selachians contain nearly all the persistent types.

This would seem to verify the assertion of some authors (*cf.*, for example, Neumayr, *Stämme des Thierreichs*, p. 106) that groups that have been overtaken by their more advanced relatives and descendants, become stagnant and either die out or continue to exist in unvariable forms. These are the genera that trail in their existence after the group when it has passed its climacteric period. This feature is well illustrated by many diagrams seen in works on fossils showing the range of divisions and having in general the following form¹:

¹ As seen, for instance, in the diagrams given by Beecher for the ranges of the orders of the trilobites in Zittel-Eastman, p. 638. Also Walcott, *Cambrian Brachiopoda*, U. S. Geol. Surv. Monogr. 1913, p. 316.

All the lower classes that in their turn have been overtaken by more rapidly developing dominant classes are more or less in this persistent, stagnant condition. Thus, the cephalopods, the ganoid fishes, the amphibians and reptiles have successively dominated, been overtaken and become stagnant in most of their subdivisions. Among the plants the Lycopodiaceae and Equisetaceae have the characters of typically persistent and stagnant groups.

Types of this class were variable at first and became persistent later in the phylogerontic stage of the class.

3 A closer study of the phylogenetic relations of the persistent genera shows, however, that frequently they form a *central primitive stock* from which numerous shorter lived genera branch off, while they themselves continue vigorously to the end. Such a genus is, for instance, Eurypterus among the eurypterids. It persists from the Ordovician to the Permian and is the most common and most vigorous genus of the order, which dominates in numbers of species and individuals its relatives and descendants. Many other such persistent, vigorous genera could be named, such as Cidaris, Camarotoechia, Leptaena, Spirifer, Leda, Nucula, Modiolus, Lima, Ostrea, Mytilus, Pholadomya, Murchisonia, Strombus, Cypraea, Tellina, Platyostoma, Loxonema, Fusus, Murex, Oliva, Pyrula, Geisonoceras, Poterioceras, Spyroceras, Kionoceras, Calymmene, Primitia, Cypridina, Carcharodon, Lamna. All these persist through many periods and are everywhere among the vigorous dominant forms. It should be noted that these genera not only show their virility in their persistency, but also in their cosmopolitan distribution. In contrast to these primitive long-lived central stocks stand the aberrant groups which, as a rule, die out in short time.

4 In general it seems true that all specialization which restricts and adapts the types to certain narrow conditions of life, while producing a short period of luxuriance, leads to extinction when these conditions change.

In contrast with these restricted and changeable conditions stand (1) the *stable conditions of the open ocean and deep sea*, as shown by the remarkable immortality of the genera of the Foraminifera, and (2) the *subterranean conditions*. Types that bury themselves out of sight, both on land and in the sea, seem to tend to become persistent. This is shown by such genera as Lingula, the persistence of the boring pelecypods (Lithophagus, Carboniferous-Recent; Pholas; Teredo, Jurassic-Recent), scaphopods, the

mud-burrowing trilobites *Conolichas*, *Hoploichas*, and also by the many relicts of extinct groups among the recent burrowing animals, as *Amphioxus*, the *Caeciliae*, *Limulus*, etc. Even among the extremely variable insects we find in the cockroaches, which are given to a secretive life under stones and logs, a group of remarkable persistence of characters which have changed relatively little since Paleozoic time.

5 A perusal of the percentage table shows further that *the sessile forms contain more persistent types than the vagile benthos*. Thus the Corals have 15 per cent, the Byrozoa 22 per cent, the Cirripedia 20 per cent. Likewise many of the immortal and very long-range persistent types in the other classes are more or less sessile forms, as *Crania*, *Schizocrania*, *Pholidops*, *Spirorbis*, *Ortonia*, *Serpula*, *Terebella*, *Ostrea*, *Chlamys*, *Camptonectes*, *Entolium*, *Pseudamusium*, *Platyceras*, *Capulus*, *Acmaea*, *Patella*.

On the other hand, the sessile sponges and Crinoidea show but relatively small percentages of persistent forms.

In the case of the sponges we are sure that the Paleozoic forms are only very imperfectly known owing to the sporadic occurrence of the sponge fields. Thus the Dictyosponges, which in the New York Upper Devonian have furnished a great variety of forms, are only rarely met with elsewhere (Carboniferous of Mississippi valley, Devonian of France and Poland) and their range is therefore probably greater than known at present. The Hexactinellid sponges which culminated in the Jurassic and Cretaceous time, have withdrawn into the greater depths of the oceanic basins and through this different habitat undoubtedly been forced to change. The Crinoidea display a great multitude of rapidly developing, short-range forms in their climacteric period in the Carboniferous; their persistent types do not appear until later.

It is further noteworthy in this connection that the Rudistae, typically sessile pelecypods, and the *Richthofenidae*, most remarkably modified, sessile brachiopods, were extremely short-lived. In both cases we have groups that were widely divergent from the primitive central stock of their classes, and it can be claimed as a general proposition that groups that diverge widely from the median expression of a class do not become persistent.

A distinct example of the different influence of the sessile and vagile modes of life on the longevity of forms is furnished by the graptolites. The writer has in other places shown the contrast between the Dendroidea which remained sessile to the sea bottom and

the Graptoloidea which became first pseudoplaktonic, being sessile to seaweeds and later free-drifting or floating. Among the Dendroidea, Dictyonema persists from the top of the Cambrian to the Carboniferous, while among the Graptoloidea we meet kaleidoscopic changes throughout the Ordovician and Silurian, the cause of this rapid development having been the departure from the sea bottom and the suspended position of the colonies.

In general it can be asserted that the sessile mode, if taken up by a whole class, tends to persistence of the types. This inference would, at first glance, seem to disagree with the previous conclusion that stability of physical conditions is essential to the persistence of types; for sessile forms are largely found in the littoral zone because there the physical conditions most require sessility. But since these same conditions are there also most apt to change, it follows that by becoming sessile, types would seem to expose themselves to early extinction. If the conditions of existence change, the organisms can react only in three ways. They either die out or emigrate or adapt themselves. The last reaction leads to new forms. There is hence left only emigration, and this would seem to be the very road to salvation which the sessile forms have closed to them. But it is to be considered here that the principal change of the littoral zone consists in its wandering up and down the continental shelf through the relative movements of the oceans and continents which take place so slowly that the sessile forms, which, moreover, are as a rule provided with very mobile young growth stages, are well able to follow them, as instanced by the persistency of the littoral corals.

Another factor of the persistence of the sessile forms lies, in our view, in the hard and massive protective covering which most of these types had to develop and which tends to counteract the variability otherwise induced by changing conditions.

6 A further inference that appears distinctly in the percentage table is that *the persistent types, as defined here, prevail in much greater number among the marine forms than among the land and fresh-water animals.* This is shown by the 11 per cent of persistent Pulmonata as against the 30 per cent of the other Gastropoda and by the scarcity of persistent types among the old classes of Arachnida, Myriapoda and Insecta, the only persistent arachnids, for instance, being found among the marine Merostomata. This could be *a priori* inferred from the fact that the climatic and physical conditions in general have changed much more frequently

and thoroughly on land through glacial periods, mountain folding, etc. than they did in the oceans.

Nevertheless we find some remarkable cases of persistence on the continents, as that of *Ceratodus*, ranging from Triassic to recent time, and of *Diplomystus*, a teleost which arising in Cretaceous time still exists in the rivers of New South Wales and of Chili; of the phyllopod *Apus*, persisting since Triassic time; of the pulmonate genera *Auricula*, *Carychium*, *Lymnaea*, *Planorbis*, *Physa*, persisting since Jurassic time.

Among the continental forms again *the limnal and fluviatile forms appear to be more persistent than the terrestrial forms*. This is indicated by the greater number of persistent limnal snails (as *Lymnaea*, *Planorbis*, *Physa*); such very ancient Phyllopods as *Estheria* and *Apus*, and the fact that all the relicts (see below) among the ganoids and amphibians (*Phanerobranchia* and *Cryptobranchia*) are fresh-water forms. It is possible that this greater persistency is only apparent and principally due to the greater probability of the water organisms to become entombed in the rocks and thus preserved; but it is also to be noted that the limnal and fluviatile faunas are to a much greater percentage composed of the lower classes of animals which are more apt to become persistent than the higher terrestrial faunas; and finally, isolated river systems, like that of the Nile, and land-locked lakes, like those of Mexico, produce conditions clearly more isolated and favorable for the continuation of ancient types than any terrestrial regions, other than islands, can afford.¹

¹ Related to the persistent terrestrial and limnal types are the *relicts* that survive as the last of their races in slightly changed forms. They have been termed persistent types by several writers. Thus Henn (*Amer. Naturalist*, vol. 46, 1912, p. 543) has discussed as persistent forms, what we prefer here to call, with the Germans, relicts (or "Relikten"), and found that they owe their presence to their (1) insular, or (2) subterranean habitats, and (3) their insignificant size. All these features tend to shield them from the battlefields of the struggle for existence. The famous surviving Rhynchocephalous reptile *Sphenodon* or *Hatteria* of some islands off New Zealand is a striking example of such a relict. Having no fossil record of it, we can not consider it as a persistent form. Other such curious relicts of antiquity are the Australian organisms, some of which, as *Ceratodus*, date back almost unchanged to great antiquity; the primitive Insectivora, as the shrew, which are protected by their small size, and the few surviving Ganoidea, as *Polypterus*, etc.

All these relicts owe their survival principally to their isolation. Suess in the final volume of his *Antlitz der Erde* has pointed out that there are regions where the terrestrial population has not been exposed for a long time to any physical changes, transgressions and orogenic forces. He calls these *asylums* and distinguishes four, namely, *Laurentia*, *Angaraland*, *Gondwanaland* and *Antarctica*. These have not taken part in upfoldings since the Carboniferous. He shows the biological peculiarities of the asylums, of which it may be mentioned that all the oldest fish types live in them, as *Ceratodus* in Australia

(Antarctica), Polypterus and Protopterus (Gondwanaland), Lepidosiren in Brazil (West Gondwanaland), and finally Amia and Lepidosteus in North America (Laurentia).

Abel in his excellent "Grundzüge der Palaeobiologie der Wirbeltiere" (Stuttgart, 1912), has pointed out other regions as existing *Refuges* or *Sanctuaries*, namely, the Indo-Malay Archipelago where the Miocene vertebrate fauna persists till today; central Africa where the Pliocene Eurasian vertebrate fauna still persists, and the central Asiatic steppes where the European glacial vertebrate fauna still survives. He asserts that these survivals are not especially strong and resistant species, but weak and effeminate types which have disappeared everywhere where conditions of life changed, the more resistant forms having there adapted themselves and changed to new types. Inasmuch as the conditions in these "*refugien*" have not changed from those of the respective former ages, it can be claimed that the animals were not forced to change there, the lack of changing conditions not reacting upon their possible variability.

It is certainly true that insular forms, though more persistent than the continental forms show a fatal weakness as soon as they come in contact with the continental types. This is shown by the rapid extinction of many insular floras and faunas, as that of St Helena, New Zealand, etc., as soon as these asylums are invaded by the more vigorous continental types brought there by human agencies. Even faunas of isolated continents may acquire this fatal weakness, as was shown by the rapid extinction of the various South American ungulates in the middle Pliocene when South America became again connected with North America. In this case the invading host brought with it large rapacious animals which had not been present in South America.

There are no asylums for marine forms in the open oceans. It had been claimed that the Pacific ocean, in distinction from the Atlantic ocean, contained the old types or relicts, but Philippi has shown that all oceans contain a fairly equal number of relicts. It had further been claimed or expected formerly that the abyssal depths of the ocean would contain Paleozoic types. The actual fauna obtained by later dredging proved to be derived from Mesozoic forms, which fact had led to the conclusion that the deep oceans are not older than Mesozoic time. Thus Abel (p. 452) has pointed to the fact that all abyssal fishes belong to very young families. He sees the reason for the young age of the abyssal fauna in the entire extinction of the older abyssal fauna through the cold waters which during and since the glacial period have reached the abyssal depths.

On the other hand although the abyssal depths do not at present contain any forms that can be considered as persistent types of great antiquity, it is certain that the abyssal life is in such stagnant condition that no progress will take place and the entire fauna will become a persistent one. Austin H. Clark in his suggestive paper, "On the Deep Sea and Comparable Faunas," (Internationale Revue der gesamten Hydrobiologie und Hydrographie, vol. 1. Leipzig, 1913, p. 17-30, 132-46), from his study of the deep sea crinoids, arrives at the following conclusion (op. cit., p. 23):

The ocean abysses are regions of uniform and absolutely unchanging conditions: the temperature is very low, approaching the minimum at which the body liquids can be maintained in liquid form; the pressure is enormous; food, all of an animal nature on account of the absence of light, is scarce, and is, as ingested, adulterated with an enormous amount of waste matter, either extraneous inorganic or internal excess of liquid. Altogether conditions are very unfavorable for animal life, and of course plant life in any form is quite impossible. What animal life there is, existing under absolutely constant conditions, has no incentive other than internal (here as will be seen reduced to a minimum) to cause it to produce variants or to give rise to new forms, and there is not the slightest evidence that any markedly differentiated new animal type ever originated in the deep sea.

But, while the abyssal forms are now in a persistent condition, they are derived from the most vigorous stocks of former faunas, according to the studies of the same author, who states (op. cit., p. 134):

"Thus the deep-water fauna is composed of the relics of all the previous shallow-water faunas, and is in effect an incongruous and heterogeneous collection of what were once dominant, adaptable, widely spread and exception-

7 The claim which was made by Henn regarding the relicts, that they are *small and inconspicuous forms*, is also applicable to the persistent types of geologic history. The immortal forms are throughout of the most lowly organisms, as the Foraminifera; the brachiopods of the Lingula and Crania types; gastropods of the Capulus and Patella types; small pelecypods as Leda, Lucina, Nucula and Modiola.¹

ally vigorous types which, at the summit of their vigor, extended downward to depths which were physically the same as the great abysses of today; and thus the deep-water types of one area reappear as shallow-water types of another into which competing forms have never intruded, and types found from the littoral to great depths in one part of the world are confined to great depths in another."

There is no isolation in the air as there is on islands, in the rivers or in subterranean life. Hence we find hardly any persistent types and relicts among the insects and birds.

A group of ancient types has found isolation in a *nocturnal habit*. Austin H. Clark (op. cit., p. 19), in discussing the "types of faunal restriction," has pointed out this fact as follows:

"The *strictly nocturnal habit*, now known to be a characteristic of a number of fishes and other organisms once supposed to be confined exclusively to the deep sea, and long appreciated in regard to a number of diverse terrestrial groups, is an attribute of ancient types, or of types which have not been able to maintain themselves under normal conditions, and is therefore comparable to a habitat in the deep sea or in any other biologically unfavorable situation."

As typical relicts among the mammals of nocturnal habits we may cite the Proximii or lemuroids of Madagascar and India, among them the lori (Stenops) and Kobold maki (Tarsius spectrum) which has large spectacle-like eyes, and our opossum.

¹ The number of examples among the vertebrate relicts is immense; among the most striking are the insectivores, notably the shrews; the monotremes, marsupials, Xenarthrae (armadillos, ant-eater, sloths) with their gigantic ancestors in South America; the Kiwi (Apteryx) of New Zealand, as the last survivor of the gigantic Mioas; the small reptiles as the survivors of the Mesozoic giants. Animals of immense proportions are in all classes a post-cimactic phenomenon; gigantism indicates already the decline and approaching extinction of the race. Such animals lack a compensatory element in the environment, which fact leads to their destruction. The gigantic reptiles, the Dinosaurs, the gigantic crocodiles, snakes, all became extinct, but the small representatives of these orders survive. The mammals are now furnishing the giants in the whales and pachyderms, but it is doubtful whether mammals larger than man will survive. It is obvious to every one that the small forms, as the mice and shrews, hold their own better under all conditions than the larger types, just as the small mammals did in the Mesozoic age against the gigantic reptiles.

Likewise the lizards (Lacertilia) which are throughout small as compared with the extinct reptiles, are one of the latest and most flourishing side branches of the reptiles and not until now reach their climax. Among the amphibians the partly gigantic Stegocephali have become extinct in Paleozoic and early Mesozoic time, while the pigmaean salamanders and frogs and burrowing small Caecilia are very well able to hold their own against the higher reptiles, birds and mammals.

Special notice in this connection is deserved by the remarkable Phanerobranchia with exterior gills (represented by the Axolotl, Siren, Proteus, Menobranchus) and the Cryptobranchia with "gill-apertures" (Amphiuma, Menopoma, Cryptobranchus). These remarkable relicts are *persistent ontogenetic stages* of the salamanders, as is especially shown by the Axolotl (Siredon) which under certain circumstances may change into a salamandroid form. It is also interesting to note the asylums these strange relicts have

8 *Many persistent types* whose geologic history is well traceable in the rocks *show a slow development*, a distinct climacteric period and a long postclimacteric period. Good examples of such genera are the bryozoan *Berenicea* which is "rare in Ordovician, very abundant in Jurassic and Cretaceous, less frequent in Tertiary and Recent"; the coral *Halysites* which begins in the Ordovician, culminates in the Silurian and extends into the Lower Devonian; the echinoid *Cidaris* which appears in the Permian, is very abundant and variable in its climacteric period in the Jurassic and Cretaceous and persists until today; the worm *Serpula*, which appears in the Silurian, culminates in the Mesozoic and still persists; also the Paleozoic representatives of *Lingula*, which begin in the Ordovician, culminate in the Silurian and Devonian, and decline in the Carboniferous and Permian; the ostracod *Bairdia* which develops in the Ordovician, reaches its maximum development in the Carboniferous and then continues in diminished numbers until the present day. The diagram of such slowly developing long-range genera would appear like this:

We believe that the life history of most long-lived genera when fully known will be found to have possessed this mode of development, in contrast to all rapidly developing genera which as a rule disappear as quickly, either by changing through their variability into new genera or by extinction. This contrast is well shown in the Cephalopoda by the difference between the slowly developing Nautiloidea with their fair number of persistent genera in a relatively small number of genera (12 in 170) and the Ammonoidea, which are so variable that they count 452 genera and change so rapidly that they have no persistent forms.

Connected with the preceding factor of persistence in genera is the following fact: that the *persistent genera which slowly develop never produce many species during a single geological period*. Genera that produce a great number of species, as a rule become soon extinct by progressive development to new generic groups and a crowding out of the older primitive stock by the descendants.

9 There are a number of *minor factors* that pertain to great longevity in the organic world and that are clearly present in some of the persistent genera. (a) One of these is an extreme *individual*

found, as, for example, *Proteus* the subterranean caves of Carinthia in Austria, *Siredon* the land-locked lakes about Mexico City, *Cryptobranchus* the volcanic lakes of Japan, and the others the asylums cited by Suess.

vitality. To cite one example: Schuchert comments on the wonderful vitality of *Lingula* and *Crania*. He states *Bul. Geol. Soc.*, vol. 22, 1911, p. 263):

It is also desirable to point out here the wonderful vitality of the living inarticulate brachiopods. *Lingula* is exposed on the tidal flats of Japan for hours without injury, and on account of its accessibility is regularly gathered by the poorer people for food. At high tide these animals are covered with 3 to 4 feet of water. Their habitat may be brackish or foul with decomposing organic matter, even to such an extent that all other shell fish may be killed off, but *Lingula* will continue to live under such adverse conditions. Yatsu, who has studied living *Lingula*, tells us that on little estuaries in certain bays of southern Japan their habitats may be covered by sand and mud brought down by stream freshets, so that all of the burrowing shell fish will be destroyed, but *Lingula* will still live in such stinking places and the individuals tunnel themselves to the surface. The burrows are from 2 to 12 inches long, and the movements of the animals up and down in the holes are made by means of the highly contractile and regenerative peduncle. It is thought that *Lingula* may attain an average of 5 years or even more. Yatsu kept them alive in aquaria with the water fetid, and Morse did the same, keeping his specimens alive for six months in almost unchanged water. Joubin kept *Crania*, taken from great depths, alive in jars under very adverse conditions for 14 months. In these statements we see the very adverse conditions under which the burrowing *Lingula* may live, and that the tenacity of endurance is also very great with cemented *Crania*. In this adaptability lies the probable explanation of why the lingulids and craniids have lived since the Ordovician. *Lingula* and *Crania* have endured all of this vast time apparently without change other than the superficial ones of form, size and ornamentation.

b Many of the still existing persistent forms are known to produce *immense broods*, as *e. g.* *Ostrea* and *Limulus*. Of the latter it is told that the quantity of eggs deposited on the sandy shore of New Jersey is so great that scows loaded with supposed shore-sand were found to be filled with *Limulus* eggs and had to be reemptied when the sand became alive! Also some of our noted relicts are remarkable for the great quantity of the eggs they produce, as, for example, the sturgeon.

c Further, it is sure that many of the persistent forms are *caters of carrion and refuse* and thus being easily fed are able to subsist where other more fastidious types had to leave. The *Capulidae*, which already in Carboniferous time began to live on the excrements of crinoids, and the oyster, exemplify this group.

Persistence in Species

Before attempting a synthesis of the factors obtained by an analysis of the persistence of the genera, we will, in order to obtain a wider view of our problem, briefly survey the persistence

of the smaller units, the species, and also that of the higher units, the families and orders.

The longest ranges are again found among the Foraminifera. We cite here, to illustrate this striking persistence, the following cases mentioned by Bagge:¹

Anomalina ammonoides (Reuss).....	Cretaceous — Recent
A. grosserugosa (Gümbel)	
Bolivina textilarioides Reuss.....	Cretaceous — Recent
Bulimina pyrula d'Orbigny.....	Triassic — Recent
Cristellaria crepidula (Fichtel & Moll)	Triassic — Recent
C. rotulata (Lamarck)	Triassic — Recent
Discorbina turbo (d'Orbigny).....	Cretaceous — Recent
Gaudryina pupoides d'Orbigny.....	Cretaceous — Recent
Globigerina bulloides d'Orbigny.....	Devonian — Recent!
Lagena acuticosta Reuss.....	Cretaceous — Recent
L. globosa (Montagu)	Carboniferous — Recent!
L. gracilis Williamson	Cretaceous — Recent
L. marginata (Walker and Boys)....	Cretaceous — Recent
L. sulcata (Walker and Jacob).....	Silurian — Recent!!
Marginulina costata (Batsch).....	Lower Jurassic (Lias) — Recent
M. glabra d'Orbigny	Lower Jurassic (Lias) — Recent
Miliolina oblonga (Montagu).....	Cretaceous — Recent
M. tricarinata (d'Orbigny).....	Lower Cretaceous — Recent
Nodosaria communis (d'Orbigny).....	Permian — Recent
N. consobrina (d'Orbigny)	Cretaceous — Recent
N. farcimen (Soldani)	Permian — Recent
N. pauperata (d'Orbigny)	Lower Jurassic (Lias) — Recent
N. soluta (Reuss).....	Cretaceous — Recent
Nonionina scapha (Fichtel and Moll)..	Cretaceous — Recent
Orbulina universa d'Orbigny.....	Lower Jurassic (Lias) — Recent
Polymorphina compressa d'Orbigny....	Lower Jurassic (Lias) — Recent
P. problema d'Orbigny.....	Lower Jurassic (Lias) — Recent
Pulvinulina elegans (d'Orbigny).....	Jurassic — Recent
P. repanda (Fichtel and Moll).....	Cretaceous — Recent
Textularia agglutinans d'Orbigny.....	Cretaceous — Recent
Truncatulina lobatula (Walker and Jacob).....	Carboniferous — Recent
T. ungeriana (d'Orbigny).....	Cretaceous — Recent
Vaginulina legumen (Linnaeus).....	Triassic — Recent

Among the brachiopods such types as *Atrypa reticularis*, which ranges through the Silurian and Devonian throughout the world, and *Leptaena rhomboidalis*, which ranges from the Ordovician (Trenton) into the Lower Carboniferous (Waverly) in America and Europe, come here readily to mind. Also the coral *Halysites*

¹ Rufus Mather Bagge jr, *Pliocene and Pleistocene Foraminifera from Southern California*. U. S. Geol. Surv. Bul. 513. 1912. p. 15ff.

catenulatus which appears in the Ordovician, flourishes in the Silurian and still persists into the lower Devonian, may be cited here. Some of these, as Halysites, belong under the heading of persistent sessile forms; the others, as *Atrypa reticularis* and *Leptaena rhomboidalis*, are clearly forms of extreme robustness and fertility but slight variability.

That the persistence of these species is but more or less relative was interestingly brought out in a discussion at the New Haven meeting (1912) of the Paleontological Society, when Prof. H. S. Williams mentioned *Leptaena rhomboidalis* as a form that is persistent because it is a form of great plasticity and very variable in every locality and horizon where it occurs; therefore, he believes it has not been separated although its differences are as great as those of several genera, like *Leptostrophia* and *Stropheodonta*. Dr E. O. Ulrich asserted that it is not so variable in each place, there being but little variation of individuals, but that it is made up of a multitude of species of different horizons that can be distinguished. Dr A. F. Foerste has, indeed, distinguished some of these species. The fact that *Leptaena rhomboidalis* has so long been left undivided by paleontologists who are ever ready to distinguish species would still indicate that it represents a long-existing compact group of little changing forms of a relatively persistent type.

Persistence in Higher Groups

There are also a number of *families and orders* that are remarkable for their wonderful persistence without material change. Such are the limulids among the Merostomes, which begin in the Devonian; the scorpions, arising in the Silurian and culminating in the Carboniferous, but still in vigorous existence today with but little change; of the Carboniferous Eoscorpium it is stated (Z. E. p. 788) that it does not differ in any important respect from living forms; the Pedipalpidae, known in a considerable number of types from the Carboniferous and but little different today; the cockroaches which, with 300 species from the Paleozoic of North America alone, were then the prevailing type of insects and still flourish but little changed, the true Blattinidae beginning in the Mesozoic; various families of the bryozoans, especially of the Cyclostomata; the lingulids etc.

The causes of persistence here applied to the genera also hold true in a more generalized form, for the larger groups. In some cases, as in the scorpions, a superior set of offensive and defensive arms (the pincers and poison glands), early developed, have

greatly helped to give the group stability; in others, the limulids, the burrowing habit combined with an excellent leathery defensive armor have allowed the little offensive and sluggish animals to persist through an astonishing length of time.

The whole class of turtles which, in contrast to the Dinocerata, still flourishes today, although already arising in the Triassic, is an example of a group that has successfully *specialized for protection* and thereby survived, while the Dinocerata, in spite or in part because of their gigantic dimensions, are extinct (Wieland).

Persistent Types Originally the Most Vigorous Stocks

We have seen that a great number of persistent types and relicts have found isolation in restriction to regions with a minimum of ecological competition, that is, by withdrawing to greater oceanic depths, to a burrowing habit, to underground water on land, to islands, to lakes and old rivers of ancient continents (as *Ceratodus* in Australia and some fishes of Africa), to very saline water, to a nocturnal habit, etc. All these persistent forms are to be considered as senescent types which are in a very delicately balanced condition and would quickly succumb if younger and more vigorous forms should intrude upon their ecological territory. While they thus now appear as weak forms, *they were, however, originally the most vigorous stocks* which were able to reach and adapt themselves to the more abnormal conditions at the periphery of the ecological field. It is not probable that a mature or senescent form can be forced into new territory; when subjected to competition by younger and more vigorous species it merely dies away. This relation of the old types to the younger types still in process of evolution has been clearly recognized by Austin H. Clark (op. cit. p. 136ff) from his studies of recent crinoids. He writes:

It must be remembered that, although we are at present concerned only with deep-sea forms, internal specific pressure due to enormous increase in the numbers of individuals within a species operates not only to 'cause a species to colonize bathymetrically undesirable locations, or unnaturally cold and uncongenial regions such as the polar seas, but also to force species into small localized areas, or as it were pockets, possessing special and circumscribed unfavorable characteristics where they may be able to remain uninfluenced by the changes in the general fauna of which they once formed an integral part. Thus we find such genera as *Artemia*, and in fact all the phyllopod crustaceans, *Carcinoscorpius*, *Tachypleus*, *Xiphosura* (collectively known to palaeontologists as "*Limulus*"), *Lingula*, and many others occupying special areas into which no competing younger forms have ever forced themselves. . . .

Living under the normal conditions, which are fixed and vary only very slightly in all parts of the world, we find the vast majority of phylogenetically new forms with a few still vigorous less young types; under the conditions grouped in the second heading, which show an almost infinite variation, we find the vast majority of all the older forms still persisting, and a very few of the more recent types.

If we are ever to find recent representatives of such past types as the cystideans, blastoids, trilobites or eurypterids we shall find them living under abnormal conditions to which they became adapted when at the height of their vigor and from which no subsequently developed competing type has succeeded in ousting them. We must look for them in the deep sea, in fresh, very saline, acid or alkaline water, in regions of great cold, great heat or great climatic change, or in some such situation far removed from the optimum conditions under which marine life is maintained. It is probable, however, that none of these types were possessed of such vigor that they were able to colonize localities of such a nature that they could not be reached by competing forms of later development or with a subsequent period of maximum vigor.

Summary of Factors of Persistence

In summing up, our evidence appears to show that the lower classes and within each class again, the lower divisions tend to have more persistent types than the higher ones, or in other words, that the groups that have been overtaken by their more rapidly advancing relatives are apt to become stagnant and persistent; as a corollary, persistent types appear more frequently after the climacteric period of a group than before or during the same; in some cases, however, they clearly form the central vigorous stock from which the shorter lived types branch off. In such cases they are primitive types or forms that vary little from the general class-type in contrast with the aberrant and specialized types which as a rule are short lived, however well adapted they may be to special conditions. Sessile classes, further, show a greater number of persistent types than vagile forms; the persistent types prevail more among the marine forms than among the terrestrial or fluvial types. Isolation, as by a subterranean habitat was further recognized as favoring longevity of types. On the continents the absence of transgressions of the sea and orogenic movements through long stretches of geologic periods have been favorable to persistence of types (asylums). As factors contributory to generic longevity were further mentioned small and inconspicuous size, individual vitality, production of large broods, restriction to most easily procurable food. In some cases the early development of superior offensive and defensive arms appears to have been of great effect in making the race conservative.

If we try to reduce this multiplicity of factors to a few controlling agents, we find that these are the fixation of overtaken and postclimacteric types, the presence of *stable physical conditions*, and *withdrawal in various ways from the fields where the struggle for existence is fiercest*. The stable physical conditions have been found by many in the open ocean, by some in the deeper littoral regions of the oceans, by others again in subterranean fields, by some in the rivers and lakes of continental regions that remained undisturbed from folding. Withdrawal from the struggle for existence with other organisms has been accomplished by a variety of means, as by isolation, burrowing life, small, inconspicuous size, superior, often deadly, offensive and strong defensive arms, through restriction to poor fare, great power of endurance, etc.

Analysis of Biologic Factors of Persistence

In any analysis of the biologic factors that have permitted persistence in the tremendous stream of organisms that has evolved since the Paleozoic age, we must distinguish between the two entirely different groups of persistent types mentioned repeatedly, (1) the postclimacteric types, and (2) the primitive central vigorous stocks.

Stable physical conditions and withdrawal from the arena of the struggle for existence, as far as possible, are the only means for the salvation of the postclimacteric persistent types; the primitive stocks, however, which persist are frequently dominant in the very seats of war. While the first group are among the "overtaken," and are mostly the gerontic groups which, though once the most vigorous of their race, are affected with a sort of congenital weakness or diminished vitality which renders them less fit for the struggle for life, the second group frequently contains what Beecher has termed "radicles" or the stocks from which the specialized groups continually branch off, while they live on vigorously though primitively. We will term the first *persistent terminals* the others *persistent radicles*. The first class has reached fixity; the latter retained variability.

A partial explanation of the possibility of the existence of two such radically different groups of persistent types we may find in the views of Simrott.¹ According to this author: "Organic evolution is dependent on the action of two opposing factors: that of

¹W. Simrott. The Fixation of Character in Organisms. *The American Naturalist*, 47: 705-29. 1913.

progressive fixation which tends universally toward greater rigidity and conservatism in all characters during evolutionary advance; and that of natural selection, which tends to maintain or increase the variability of those characters important for survival by eliminating individuals where such characters have become so fixed that the organism fails to possess a necessary degree of adaptability."

According to this conception it is possible that the persistent types which, so far as they belong to the class of postclimacteric forms or fixed terminals and are not among the dominant forms, have become so fixed in all their characters as to make them persistent, partly by the factors of progressive fixation and partly by the fact that they have in various ways, as we have shown, avoided the opposing factors of natural selection which otherwise would have maintained their variability. Their conservation is then due in part to their gerontic condition and in part to the comparative constancy and peacefulness of their surroundings.

In the central, frequently dominant stocks, or the persistent radicles, the persistence, on the other hand, is the result of the fact that through their primitive nature they are still adapted to a greater variety of conditions and that while there may be and probably always is considerable variation, it is around a still unspecialized, primitive form and thus difficult of recognition, and further that the plastic and variable characters which, according to Simrott, are essentially those of size, shape, color and texture, are not always quite apparent or observable to the paleontologist, especially where the hard parts are not readily affected by the variations in the soft parts.

If this conception is true, only the persistent terminals will be *actually fixed* and are *true persistent types*, but it would also appear that the taxonomic characters, by which we recognize them as persistent, are of little or no functional influence.

Seen from another angle, that of the physiologist, the problem resolves itself into one of difference of selection of adaptability. Albert P. Mathews¹ writes as follows:

In the evolution of animals two movements may be perceived: a spreading out and a progress; a diversification and a movement forward. The question which I wish to raise is whether these two movements which are at right angles to each other, may not be due to the natural selection of two different kinds of adaptation; first, adaptation of form and function to different kinds of environments; and second, the natural selection of the func-

¹ Adaptation from the Point of View of the Physiologist. *American Naturalist*, 47: 90ff. 1913

tion of instability, or, in other words, to the selection of adaptability, or the adaptation to changeableness of environment. Selection of the first kind of adaptation may have given rise to varieties, species, genera of the same type of animal, and have produced spreading or diversification, while selection of the second kind of adaptation may have produced the movement onward and upward of all animal forms.

The two kinds of adaptations do not always go together and selection of the one may outweigh the other. It is because selection to a specific environment sometimes is more important than selection of adaptations to changeableness, that not all organisms have progressed in the scale of evolution equally rapidly; but some have persisted in special environments with slight changes of structure for very long periods, or may even have retrogressed; while other forms in which the second adaptation has been vigorously selected, have moved rapidly onward and upward, and show little adaptation to any special environment.

The clearest conception of the biogenetic causes of persistence we obtain, it seems to me, through Osborn's law of the four inseparable factors.¹ This fundamental biological law is: "The life and evolution of organisms continuously center around the processes which we term heredity, ontogeny, environment and selection; these have been inseparable and interacting from the beginning; a change introduced or initiated through any one of these factors causes a change in all."

We must then infer that since no changes or but extremely slow and insignificant ones are apparent in the characters of the persistent forms, the fundamental condition of persistence is that each of the four factors, heredity, ontogeny, environment and selection, remains constant and no changes are originated through any of them. We have already seen that environment and selection are processes which comprise all competition, survival or elimination of individuals, and which appear under different forms as important factors of persistence. Heredity is, according to Osborn, by far the most conservative and stable of the four processes involved in life and evolution, because it is embodied in a form of matter (germ-plasm) least subject to changing external influences, but it is also a fact, according to the same authority, put forth through paleontological observation, that many origins of new characters are through some internal action in heredity (both

¹ H. F. Osborn. Evolution as It Appears to the Paleontologist. *Science*, n.s., 26: 744. 1907.

Also H. F. Osborn. The Four Inseparable Factors of Evolution; theory of their distinct and combined action in the transformation of the Tithanotheres, an extinct family of hoofed animals in the order Perissodactyla. *Science*, n.s., 27: 148. 1907.

the continuous mutations of Waagen and the discontinuous mutations or saltations of de Vries). It then appears that in these persistent types the process of heredity has become entirely fixed and rigid. While heredity is the most stable of the four processes, ontogeny is the most unstable. That no changes originate from this factor, requires entire stability in the habit and the use of the organs.

Of the four factors, heredity, ontogeny and environment evidently work toward fixity after the climacteric period, since the evolutionary advance in each phylum tends to result in the decrease of variability, which becomes a hereditary character, and since the early ontogenetic stages repeat these characters which were most conservative and firmly fixed in their ancestry, this condition progresses into later and later ontogenetic stages and leads thus to a loss of the potentiality of introduction of new characters during ontogeny. The environment in all postclimacteric persistent types is notably stable.

But while in persistent types heredity, environment and ontogeny are rigidly stable factors—heredity especially to be considered as fixed in the postclimacteric forms—selection can not be fixed but is still ready to act whenever the other factors introduce slight variation. It then follows that the possibility of slow development continues and that all persistent types may still develop, perhaps infinitely slowly. There are, then, theoretically *no absolutely persistent types*, and the differences but those of rate of development.

The difference between the two groups of persistent types, the relatively rigid terminals and the more variable radicles, consists according to this view in the fact that in the former all factors have become fixed and unresponsive to stimuli, only the selection still slowly acting, while the latter are so well adapted to a variety of conditions that no changes readily originate through any of the processes of environment, ontogeny and selection, which affect the whole stock, while at the same time no changes in the germ-plasm are induced through hereditary tendencies.

General Conclusions

The evidence here gleaned from the persistent types and equally supported by both groups of persistent types, the persistent radicles and persistent terminals, leads necessarily to the general conclusion that there is no inherent propelling force of variation or of development, and that all evolution in the last analysis is largely

dependent on the exterior agencies supplied by the ever changing physical conditions, which stimulate the four inseparable factors of evolution. As seen from the side of the persistent forms, variability and development in the organic world stop when the physical conditions become stationary.

This conclusion from the persistence of types is corroborated by evidence from the opposite phenomenon, that there are periods of rapid development under the stress of severe and rapidly changing physical conditions, such as, for instance, obtained in the periods of maximum emergencies of the continents that separated the geologic eras.

While we stand in awe before the orderly and apparently wilful steady development of the organic world to its highest expression, man, the persistent types remind us what might have happened if the surface of the earth had remained unchanged and unchangeable, if the advancing and receding seas, rising and sinking continents and mountain ranges, drying up seas, rivers and lakes, changing climates and other physical factors had not continuously subjected the organic world to new conditions and new stresses, ever propelling them forward, letting the oceanic organisms into the epicontinental seas and forcing them back again into the oceans, or driving them into the rivers and thence upon the dry land, in successive waves of worms, insects, arachnids and vertebrates; and from the dry land even into the air. There is no doubt that without these driving forces a stagnant, lowly organized world of relatively persistent types would have resulted.

GEOLOGY AND PUBLIC SERVICE¹

BY GEORGE OTIS SMITH

Director of the United States Geological Survey

The subject on which I have been asked to speak presupposes a science that is practical — one that serves others than its devotees. It is only utilitarian geology that I shall discuss — that side of the science by some termed economic geology, by others applied geology, but for utilitarian I shall take the definition credited to Tolstoi — solely what can make man better. This human side of scientific work is simply part and parcel of its wider purposes, and to recognize its utility is to ennoble Science rather than to degrade it.

Five years ago, in the presidential address of the Geological Society of Washington, Mr Brooks gave some quantitative expressions of the marked tendency in geology toward practical problems. This growth in the utility of our science during the last quarter of a century was measured by the activities of state geological surveys and of universities, as well as of the federal survey. Further, as Mr Brooks pointed out, the trend that has made applied geology the dominating element in our science has not been limited to the North American continent; it has been worldwide.

The United States Geological Survey was created for public service in the widest sense. Congress intended it to be a large factor in placing "the work of national development and the elements of future prosperity upon the firm and enduring basis of truth and knowledge." To quote further the language used in the debate of thirty-eight years ago, "the institution and continuance of an effective geological survey" was then regarded as a measure such "as will prevent the waste of natural resources, clear the way of progress, and promote the triumphs of civilization." Such a declaration of purpose, though more eloquent, was in full accord with the report of the National Academy of Sciences and surely leaves the federal geologist free to devote his science to public service without fear of just criticism.

The present status of our science forecasts an even larger usefulness in the future. In oil geology alone the profession has won a place in the business world undreamed of ten or even five years ago. When we see single corporations having in the field more oil

¹ Delivered at the Albany meeting of the Geological Society of America, December 1916.

geologists than the United States Geological Survey, we realize that our federal service must rest its claim to consideration on something other than size.

In other lines, too, the science of geology is gaining the recognition that we perhaps feel has too long been withheld. Especially gratifying is the tendency of constructing engineers to consult geologists in matters related to large engineering projects. To the trained geologist, familiar with the many kinds of rocks and their varied habits of assembling together, it has seemed strange indeed that so many engineers have gone ahead on the theory that rock is rock and that nothing can be learned of the third dimension of the earth's crust in advance of actual excavation. Possibly, however, some of this blame may be laid at our own door, for geologists do not always seem firm believers in the practical side of their own science, and only in these later years have we learned to talk of the facts of geology with any approach to the quantitative exactness that engineers expect. Even now a wide difference in degree of scientific accuracy and refinement may be noticed in the manner in which we handle data in our own particular specialty and data relating to some other phase of geology or to another branch of science. This lack of respect for specialized science may sometimes be found in our own midst, even though we call ourselves specialists.

The opportunities for expansion are plainly before us, for the practical worth of geology is now widely acknowledged. How can we best increase the contributions of geology to mankind? Has the science other possibilities? What is its relation to public service?

In the last three years it has been gratifying to see the preparedness issue broaden so as to include the contingencies of peace as well as of war, to hear of industrial as well as of military preparedness. But back of both, and indeed including both, there needs to be a more vital preparedness—the preparation for citizenship. In any day and generation this test can and should be applied to any religion, philosophy or science: Does it make good citizens? It is therefore with real concern that we ask ourselves this question: Does geology contribute to citizenship?

The president of this society, in a thought-inspiring address at the University of Chicago convocation this year, made reference to a little red-brick building here in Albany, which this city does well to preserve—the laboratory of James Hall. And I believe Doctor Clarke is right in regarding that small and plain structure as the source of broad conceptions of the philosophy of evolution,

which, radiating outward, have influenced not only our science but also your State and our country.

The sciences of geology and astronomy are founded upon postulates which they in turn have done much to make real—the permanence and universality of natural laws as we of today know them. By training and almost by second nature the geologist may be a conservative in politics; at least, the believer in natural law should possess the patience to wait for results in this particular epoch of this geologic era. By training the eye to see far back into the earth's remote past, geology can add to our power to put correct values on the events and changes in the brief present in which we happen to live.

There is another way in which geology especially contributes to the training of an enlightened citizen. Someone has said that a man's breadth of mind is measured by the diameter of his horizon. Geology as a study and especially as a profession leads to wide travel, and travel surely maketh the broad man. This advantage may seem to us so much a matter of course that we underestimate its silent influence in fitting us for citizenship. The geologist has the opportunity to think in terms of country rather than of community, of continents rather than of country; and his broader outlook over the world surely gives perspective, just as his longer view back into the past gives poise.

In an address at the University of Illinois I referred to the inspiration and incentive which come from Professor Chamberlin's conclusion that there is good reason for measuring the future habitability of the earth in millions or tens of millions if not hundreds of millions of years. This belief in the high probability of racial longevity is, as you know, the result of an exhaustive analysis of the past as revealed by geology and of the future as forecast by astronomy. But now I wish to add my personal acknowledgment to our greatest American geologist for the inspiration gained from a talk with him several years ago, when I realized that it was this scientific expectation of the evolution of humanity continuing through these millions of years that was prompting him to public service not limited to his own city or country.

The geologist's appreciation of that delicate adjustment of earth to life by means of which "life has been furnished a suitable environment for the uninterrupted pursuit of its ascensive career" and the geologist's vision of the continued adaptation of the earth to the uses of man together constitute a real call to larger service.

No one has more reason than the geologist to believe that wise utilization of nature is essential, now that man the engineer has become so effective a geologic agent; nor can the geologist overlook the need of a social organization that will adequately serve the larger and higher demands of humanity, now that man himself controls in large part the adaptation of this earth to man in his further evolution. We believe that the Golden Age is in the future, but it will be of man's own making.

This tribute was paid a year ago to the work of the geologist and engineer by one in high official position who has a vision of things as they are and are to be — Secretary Lane: "This is a glorious battle in which you are fighting — the geologist who reads the hieroglyphs that nature has written, the miner who is the Columbus of the world underground, the engineer, the chemist, and the inventor who out of curiosity plus courage plus imagination fashion the swords of a triumphing civilization. Indeed, it is hardly too much to say that the extent of man's domain and his tenure of the earth rest with you."

Keeping in mind these thoughts of the larger things of time and space, I desire to mention what may be termed the professional obligations of geologists. As scientists, working in a practical world on problems that have come to have very practical bearings, we may need to take special care that our scientific ideals be not lowered. As an associate in a large group of geologists I have been proud to see the science of geology win this larger recognition in the market place, for I hope to see our science cooperate in the further raising of business ideals. There can, however, be no double standard for geologists — one for guidance in research work in pure science, the other for purposes of professional exigency. As geology enters into the larger sphere of usefulness, there naturally come to the geologist opportunities somewhat different from those of the laboratory or lecture room. The profession in its newer activities encounters stresses for which new factors of safety must be figured. As I look at the demands now made upon geologists, the temptation to lower our ideals comes not so much when our task is to find something as when we may be called upon to prove something.

The geologist sent to South America to determine the extent of an ore body or to Oklahoma to discover an oil pool must needs bring into play every resource of a trained mind in order to wrest the truth from secretive nature. This is a contest which calls for geologic science at its best and in which scientific ideals are in no danger. A demand of another kind, however, is made upon the

geologist who is asked to certify to some doctrine in the conservation creed, it may be, or to testify in support of some contestant in a court of law. Professional demands of this type may cause our scientific ideals to tremble, if indeed they do not suffer a tumble. It is for this reason that a geologist's ideals are safer in the field than in the court room; Mother Nature is a better associate than the goddess who goes blindfold.

Yet the problem faces us and we must answer our own question: What are the professional obligations of the geologist? Possibly the official geologist is less exposed to temptations of this type: he is allowed to make his testimony follow the evidence. At least I remember that the Survey geologist published, uncensored, his estimates of coal reserves, even though his statement did not fit in with the popular argument for conservation; nor was the official opinion required by the statute as to the influence of forests on stream flow given until field examinations by geologists and engineers furnished a basis of fact; nor again do I believe that the federal geologists who testified as to the mineral character of petroleum were in any degree influenced in their opinion by the chance circumstance that this was the Government's contention. On another occasion the federal geologist whose duty it was to defend the official classification of land in a western state had definite instructions to reverse the Geological Survey's position in the matter if new evidence should indicate an error of judgment, even though such action would have enabled the railroad claimant to win the land. Nor should a Government geologist hesitate to file notice of a correction in some assays earlier introduced as evidence, even though he thereby strengthened the land claimant's contention. Here, of course, the issue was plain: the duty of the public servant was to see that truth prevailed, even though the Government might seem to lose its case. In two other of the instances I have mentioned some degree of temporary popular favor and freedom from current newspaper criticism could have been gained by a different course, but I believe that in the end the good name of science would have been besmirched.

Yet in courts of law we now see geologists testifying as experts on both sides of the case, and too often as experts on subjects on which they would not be regarded as specialists by their fellow geologists, or at least on specialized phases of geology which they themselves might hesitate to discuss before this society. But even when such opposing witnesses are both eminently well qualified,

what is the spectacle presented to the public? One expert testifies that the thing under discussion is absolutely jet-black; the other that, as he sees it, it is purest white; whereas it may be that without the legal setting the same thing would present to most of us varying shades of gray, or perhaps some one using a higher power of lens might call its general color effect rather spotted. I regret to add that this suppositional illustration is almost paralleled by an important case in which two of my own friends, both honored fellows of this society, were the opposing expert witnesses; and afterward the judge told me that he could believe neither, although he would have taken the unsupported opinion of either one had this geologist been in the pay of the court! Does not such a statement by an eminent jurist put geologic experts on a par with other expert witnesses, and would it not be a "safety first" measure for geologists to decline professional work of this type until the day comes — and I think it is not far off — when the court will summon the expert witness and compensate him for his services to the state in telling the whole truth and not that special part of the truth which favors one litigant? This society wisely put itself on record last year as recognizing the urgent need of this reform in legal procedure, but to be effective resolutions need to be adopted by each individual geologist.

As first suggested to me, the subject on which I was invited to speak today was geology in the national service, but I feared if thus expressed my topic might seem to limit opportunities for service to the nation to those of us who are on the Federal Geological Survey. The president and more than a score of other fellows of this society are in the public service as officials of the several states; and too much credit can not be given to the long succession of state geologists who for nearly a century have both contributed to the science of geology and guided the development of their states. A few years ago Doctor White, in addressing the West Virginia Board of Trade as its president, referred to the function of the state geologist as that of "a kind of mentor or guardian of the state's natural economic resources."

Yet I would not limit the obligation for public service to those of us who happen to be public servants. The use of the United States Geological Survey as a training school for professional geologists in private practice can not be regarded as wholly a hindrance to the nation's business when viewed in a large way. The spirit of public service can be carried over into the work outside the official organization, and I like to believe that there is a per-

sistence of this same purpose on the part of our Survey graduates that will lead them to do their share in planning for the utilization of the nation's mineral wealth, not merely so as to increase dividends for the corporations that employ them or to assist a few capitalists in speculative endeavors to corner some limited resource, but also so as to benefit society in a large way through future decades. Why can we not be trained scientists and professional geologists and loyal citizens at one and the same time?

President Vincent has referred to the sweeping indictment of professional schools, with all their modern efficiency, as turning out graduates "bent upon personal success and regarding the public as a mine to be worked rather than a community to be served." In whatever degree unwarranted, this criticism, as President Vincent points out, is in itself encouraging as a sign of general discontent with self-centered careers. And there is another approach to this subject of the civic obligations resting upon us as geologists. Those of us who have shared in the benefits of the American educational system, up to and including the university, must realize to what a large extent our education has been gratuitous. As Doctor Becker once expressed it to me: "Men who seek or use their university training solely for their personal advantage are almstakers. Only by public service can educated men repay the debt they incur and thus fulfil the designs of the founders."

It is a fortunate sign of the times that applied science is touching more and more upon the human and social side of its work. Measure of the breadth of view already attained in this public service idea is found in this month's issue of a leading technical journal, *Metallurgical and Chemical Engineering*, wherein the longest editorial bears the title "Expensive Slums." Social responsibility is acknowledged and civic duty set forth in the closing sentence of this editorial: "It is needful for industries that they be in good standing, and they can not maintain good standing so long as they have slum attachments."

So, too, it is eminently fitting that in a technical volume bearing the title "Iron Ores" the closing chapters should discuss the large social questions of public and private policy. The author, a geologist and fellow of this society, properly regards the social value of iron just as worthy of his thought as the purity of its ores. Indeed, it is simply the need of society that makes the mineral hematite an ore and thus the object of the geologist's special study.

In my administrative report for the past year I had occasion to refer to a professional paper by Doctor Gilbert now in press. In

his wonderfully broad and complete investigation of the mining-débris problem in the Sierra Nevada the geologist began with the antagonism of mining and agriculture, but he soon found that his research also involved questions of relative values between commerce and irrigation and power development. So this report, thoroughly scientific in data and method, will illustrate how high a public service can be directly rendered by the geologist. Nor is this a new departure: some of us belong to the generation to whom Monograph 1 of the United States Geological Survey was a source of inspiration in our student days. That monumental work by the same author, a classic in its exposition of geologic processes, was the result of an investigation also planned as the answer to an economic question of large civic importance. Director King thus stated in 1880 the purpose of the Lake Bonneville monograph: "Is the desert growing still drier or is it gaining in moisture are questions upon the lips of every intelligent settler in that region."

Moreover, aside from making our science more human, there is the larger need of humanizing ourselves. Doctor Favill, of Chicago, in addressing a group of business men last winter, gave them this professional advice: "Have an outside interest"; and the outside interest he prescribed was political or social activity. This physician regarded it as conducive to individual happiness as well as helpful to society that "every honest, able-bodied, red-blooded, clear-thinking man should have his mind set on what is the right thing for him, for his community and his country to do."

The Austrian geologist Suess may furnish the best illustration of the happy combination of scientist and citizen. He was a leader not only in the science of the world but in the parliament of his country. A close student of geologic discovery even after reaching fourscore years, Professor Suess was equally keen to learn of political progress the world over, and in a letter to me within a year of his death he inquired particularly about the reforms in public-land administration in the United States.

Appreciation of civic duties has fortunately not been lacking in American geologists: one of the best volumes on citizenship was written years ago by Professor Shaler, and it is worthy of mention that in that book he emphasized not so much the opportunities for service in high station, for he states that the best work in the practice of citizenship is done in the town or precinct. "In these fields of activity the spirit of the freeman is made; if the local life be not of a high citizenly character, all the constitutions in the

world will not give the people true freedom." And it has been said of Professor Shaler that he not only preached good citizenship, but, what was better, he never neglected his own political duty. While we must properly look upon enlightened citizenship as a 365-day-a-year undertaking, there is one day in each year, or two years, or four years when a special duty is laid upon each citizen of the state and nation, and in these times no one is better qualified to exercise the right of suffrage than the geologist. A few weeks ago, too, we learned that even in this great country of ours, where eighteen million ballots were cast at a single election, individual votes have not lost their power to influence the result. And how true it is that education of the scientific type is essential to a correct understanding of many of the issues of the day.

In a leading editorial, the day before election, a nonpartisan writer mentioned the discussion of prosperity as a campaign issue and remarked that "Analysis of the interminable political arguments about it would probably disclose that in the main they consist of about 95 per cent imagination and exaggeration, in equal proportions, 5 per cent of fact, and of unbiased opinion not a trace." A low-grade ore of that composition surely needs a citizen who is a scientist or engineer to make the necessary separation and concentration.

Take another political and economic issue that must be faced — the length of the working day. Professor Lee, of Columbia, recently emphasized the fact that the determination of the proper number of hours of work is primarily a problem of physiology, although too often economic and social considerations have been made paramount. Must we not agree with the physiologist, at least to the extent of admitting that it is all too evident that here is a present-day issue of large importance which deserves scientific rather than political treatment? Or we may say, Here is a civic question that demands the attention of citizens who have had scientific training. Who can better weigh the opposing elements of this question — on the one side the cumulative fatigue of the individual producer and on the other the economic requirements of society as the consumer?

To mention just one other of the larger issues of the moment, the railroad question is one so intimately tied up with the geographic relations of mineral resources that the geologist citizen is eminently well qualified to consider how dependent is industrial opportunity upon fair freight rates. When we realize that the railroad earnings from the transportation of the raw products of the mine alone exceed the earnings from passengers and also exceed the freight

receipts on all products of both farm and forest, we have a measure of the interdependence of the mineral industry and the railroads. The proper regulation of common carriers thus becomes a prerequisite of the full utilization of our mineral resources, and on such a political issue no citizen should have a larger interest or more intelligent opinion than the geologist. It is therefore more than a happy coincidence that President Van Hise has rendered large service to society in his contributions to the railroad and labor problems; the broad training of the geologist is being utilized in the work of the publicist.

Have I not already shown that the geologist is well qualified by his special training to serve his day and generation, not only in the capacity of professional adviser but, better than that, in the rôle of fellow citizen? It may be rather late in this discourse for me to select a text, but there is an old saying in the book of Proverbs that has been much in my mind for several months — "Where there is no vision the people perish." Imagination is necessary in our science, and it is equally essential to the larger citizenship. I believe the geologist possesses the vision; his duty and privilege is to let that vision guide him to a larger public service.

PLASTIC DEFORMATION OF GRENVILLE LIMESTONE

BY D. H. NEWLAND

Some of the most interesting exposures of the Grenville limestone in the Adirondack region are found along the shores of Lake Champlain, on the New York side, where the series of ridges that confront the lake have been cut through to afford room for the tracks of the Delaware & Hudson Railroad. The rock faces still preserve their fresh appearance in contrast with the stained and weathered condition of the limestone in natural outcrop; and the vertical sections afford opportunity for observation of the rock in mass, with its complicated structures and deformation phenomena.

The accompanying series of photographs, contributed by Prof. G. H. Hudson, reveal the conditions found in the exposures just north of Porth Henry and within the limits of the Port Henry sheet of the United States Geological Survey map. This area has been described by Professor Kemp, whose report¹ contains a description of the limestones here depicted, as is later noted.

For students of Adirondack geology the vicinity of Port Henry holds much that is of interest; no other part of the mountains probably in so brief a compass has such variety of rock formations, illustrative of the principal types as well as of their general relationships and structural features. The Grenville strata include limestone, schists and gneisses in extensive development; while of the igneous rocks occur granite, syenite, gabbro and trap, and at no remote distance also anorthosite in typical exposures. The early Paleozoic beds which once covered the crystallines are preserved in small downfaulted patches at the lakeside, ranging in horizon from the Potsdam to the Trenton inclusive. At Mineville, 6 miles from Port Henry, are the largest of the Adirondack magnetite mines.

The Grenville limestone shown in the photographs forms only a small part of the exposed area and is divided into numerous bands interbedded with quartzose, rusty gneisses and schists. According to Professor Kemp's map, the Grenville strata altogether cover an irregular area that reaches some 2 or 3 miles to the north

¹ N. Y. State Mus. Bul. 138. 1910.

and south of Port Henry and as much to the west and is bordered by bathylithic masses of syenite and granite. Of this particular locality he makes the following mention:

Along the Delaware and Hudson Railroad tracks on the lake shore north of Port Henry where there is an irruptive contact of gabbro and basic syenite and limestone one can see the igneous rock tonguing out into the limestone and apparently pinched off at times by the dynamic disturbances. While it is entirely possible that the hornblendic rocks have been derived from aluminous bands in the original sediment, which might yield greater or less amounts of hornblende, yet we are dealing with a district in which are numerous intrusions of gabbro and basic syenite and where apophyses are abundant. The marked plasticity of the limestone under pressure tends greatly to disguise the relationship and to render a demonstration difficult. Igneous phenomena and their expiring effects must have been very general and have probably occasioned widespread recrystallization. Undoubtedly they have set in migration many heated solutions.

The limestone at times becomes extremely small in amount and may be represented by little more than calcareous streaks amid more siliceous rocks, such as mica schist and quartzite bands. The more resistant silicates having been involved in a plastic medium like calcite have been bent into shapes that seem almost beyond the power of brittle minerals to assume. The presence, however, of the limestone is indicated by the pitted and cavernous weathering.

Along the lakeside for the first mile or so north of Port Henry the Paleozoic beds alone are exposed, the strata representing a triangular block of which the western edge runs diagonally to the lakeshore and comes out to the lake in a little cove known as Craig harbor. Here they terminate suddenly in a single great fault which brings the Beekmantown beds on the south side in line with the Precambrian on the north side of the cove. The faulted beds dip toward the crystallines at a low angle. The two series are separated by the width of the cove, but the well-marked escarpment on the north side probably corresponds nearly to the plane of the fault; while the interval is represented by brecciated Beekmantown which by its rapid weathering has formed the embayment. A view of the fault-scarp on the north side of Craig harbor is shown in plate 1. This reveals the Grenville limestone in heavy beds resting upon a gneissic hornblende rock which at a little distance from the contact grades into recognizable gabbro. The contact, therefore, is igneous, but there is nothing to show the intrusive nature of the gabbro in the way of reaction effects upon the limestone or of offshoots of the gabbro into the latter. It is very likely that movement has occurred along the contact through underthrusting of the block of gabbro, causing the less resistant limestone to



Fault scarp north side of Craig Harbor near Port Henry, exposing Grenville limestone at left overlying syenite gneiss at right. The down-thrown Palaeozoic strata are concealed below the waters of the inlet.

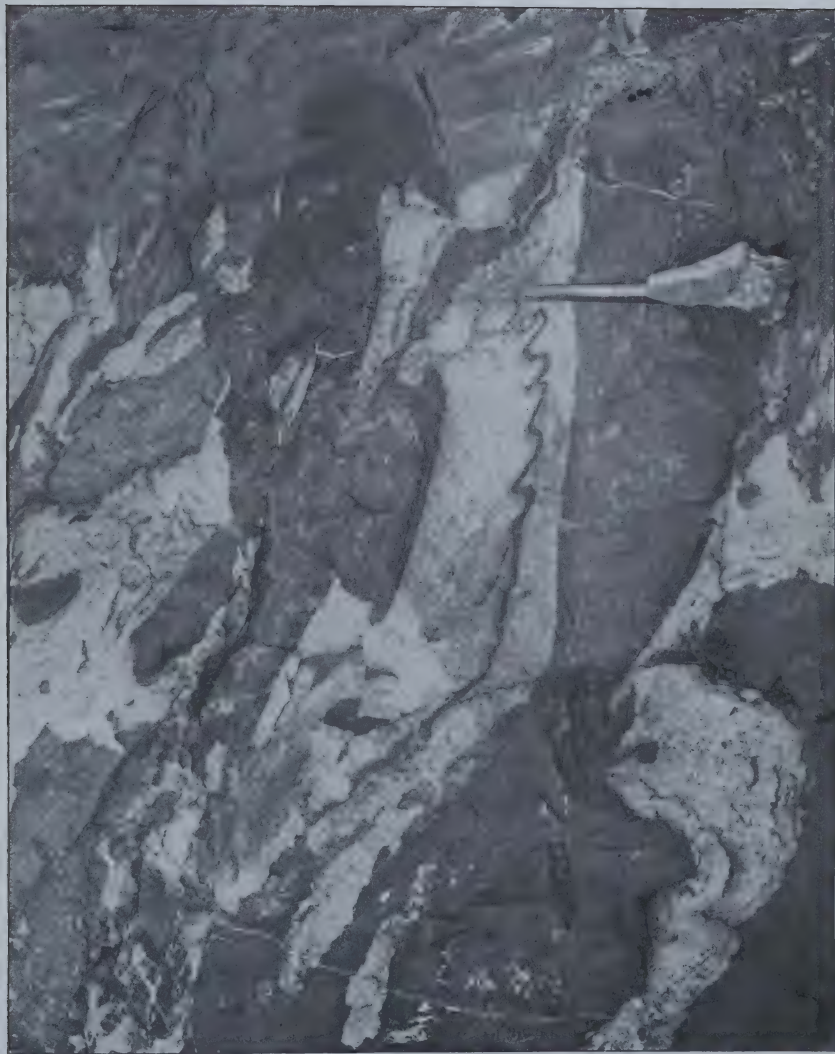
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Plate 2



Amphibolite band folded and disjunct in unbroken and massive limestone. Near
Port Henry



... A shattered band (dike?) of amphibolite, recemented by plastic flowage of the limestone from the walls, Fort Henry

ride over the upper surface of the intrusive. The relations are interesting in that they give a clue probably to the extreme contortion and flowage effects exhibited by the succeeding photographs which are taken a little farther north in a second exposure of the limestone. The gabbro forms only a small boss and is succeeded by syenite gneiss in which occurs a band of limestone that forms the shore line for nearly a mile. It is in this area that the freshest faces of limestone are found.

The deformation that is revealed in the pictures is no doubt the result of squeezing between the more resistant igneous rocks which themselves have assumed more or less cataclastic and gneissic characters under the strain. The effects could only have been accomplished under conditions of cubic compression such as would be supplied by a thrust exerted upon the beds when they were heavily loaded or weighted down by many thousands of feet of cover.

The nature of the silicate bands in the limestone is something of a problem, as is remarked in the citation from Professor Kemp's bulletin. It is not unlikely that some of the bands are dikes derived from the gabbro and syenite magmas, as instanced by the dark amphibolite bands which in appearance and mineral character are scarcely distinguishable from the border phases of the basic intrusions. This type is illustrated by plate 2 in which is seen a small band of black amphibolite that has been folded and broken up under the pressure transmitted by the mobile limestone, itself giving no evidence of the deformation that has taken place. In plates 4 and 5 the bands are in part of a more siliceous character, and may well represent original impure layers in the beds.

Plastic deformation of the Grenville limestones is a common condition throughout the Adirondacks, if one may base an inference upon the circumstance that it is the purer beds alone that do not reveal its effects; in them the results would be masked even if present.

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Plate 4



An exposure of siliceous limestone in which the silicate layers have been stretched, disrupted and folded under cubic compression. Cheever dock, near Port Henry

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Plate 5



Limestone with bands of dark siliceous material which show disruption and folding. Near Port Henry

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Plate 6



Recumbent isoclinal folds in the Grenville limestone. Near Port Henry

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THE INTERESTING GEOLOGICAL FEATURES AT THE CHAMPLAIN ASSEMBLY, CLIFF HAVEN, N. Y.

BY GEORGE H. HUDSON

Visitors reaching the grounds of the Champlain Assembly by the Delaware and Hudson Railroad must notice that the last few miles of the journey are over an exceptionally level roadbed. The land at Cliff Haven is spread out like a plain which tips gently toward Lake Champlain with a drop of about 1 foot in 90. One marked exception to this general and rather widespread flatness of surface is the large rocky elevation on which the Hotel Champlain stands, elevated nearly 150 feet above the eastern edge of the assembly grounds.

If the visitor arrives by boat he will observe the very marked irregularity in the Lake Champlain shore line which is caused by the position of this elevated area, for here the lake is not only bordered by high and vertical rock cliffs, but these project into the lake itself, a part of the cliff face being nearly a mile east of a straight line connecting the Champlain Assembly bathing beach with the mouth of the Salmon river; hence the name "Bluff point."

A student of nature may well ask himself the reason of this great elevated rock mass to the south, now beautifully clothed with woodlands, affording a veritable sanctuary for birds and a flora of unusual interest. What were the forces which gave rise to this rock barrier, with its long and protecting seaward arm (shown in figures 1 and 2), and to the recess on the north, with its beautiful bay and sand beach so well protected from the waves of a "south blow" and forming a veritable "Cliff Haven"?

The thoughtful student should first of all visit the apex of the somewhat acute angle where the beach meets the cliff (indicated by arrows in figures 1 and 2) and there note the great difference in character between the kind of rock forming the south cliff and the kind of rock lying in contact with it on the north. A view of this contact is given in figure 3. The rock on the north side (the right) consists of sheets of a hard but brittle limestone with many partings of weak shale. This rock belongs to the Trenton formation and crumbles readily and rapidly under the action of frost, water, and the roots of trees. In the early spring the lake also reaches the cliff base (see figure 4) and lake ice and wave action help to break down this wall. That this wall is receding rapidly will be realized by

noting the overhanging turf and tree roots (figure 3). Recent rock falls may also be noted at *a* and *b* (figure 4). A direct comparison should be made between the cliff itself and the view of it which is here presented.

The rock which forms the south cliff offers very marked contrasts to the Trenton which rests against it. It has successfully resisted the same influences which are so rapidly destroying the Trenton beds. The southern wall belongs to the Chazy formation, older than the Trenton. This stone is so good for building purposes that it was once extensively quarried here. When the United States spent a million or so in building Fort Montgomery (on the Canadian side of the United States boundary) the Cliff Haven stone was chosen on account of its excellent quality and many a fine block was taken from the now abandoned quarry just around the point shown in figure 2 and loaded on boats which were tied to a dock built for that purpose just outside the same point.

The answer to our first problem should now be apparent. The softer rock has been eaten away by the "tooth of time" while the harder rock has offered more effective resistance to all eroding agents. The bay and the protecting wall to the south are the result. If further evidence is desired one has but to ask why an artificial stone wall was built along a portion of the beach front and why to the north of this several breaches in a boulder-built wall were repaired and further fortified in the fall of 1916. The effects of wave action on a weak shore line are manifested in numerous localities between Plattsburg and Cliff Haven. In many places the Delaware and Hudson Railroad has had to build a sea wall and residents of Plattsburg can remember recent landslides which carried forested portions of the higher banks down to the lake level, where the waves of new storms could take care of the débris.

As soon as the student gets an answer to his first question he will be ready to ask another. How fast has the Trenton rock been receding and where was the shore line of this bay when the discoverer, Champlain, first passed through the lake? This question will not be so easily answered as the first. Quantitative analysis is always more difficult than qualitative. The former, however, usually yields results of the greater value. We may here point out one or two lines of investigation that will yield an answer to this question.

At *a* in figure 3 we may note what remains of a small tree whose age, at the time its trunk was lopped off by an axe, could be readily determined by counting its annual rings. When this tree started



Fig. 1 Distant view of south shore of bay at Cliff Haven; Hotel Champlain dock next left margin

Fig. 2 Nearer view of same; Trenton beds at right of arrow, Chazy cliff at left

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Fig. 3 View of fault at Cliff Haven. From a photograph by the author in 1916.



Fig. 4 View of Trenton beds north of fault, showing the action of various agencies which have long been destroying the cliff and causing its recession

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to grow it must have been at least a few inches within the border of the bank. Those of its roots which were directed lakeward may be made to tell approximately how far. At present the old stump has no support and is held in place only by a rather long and strong landward root. There is direct evidence here of a quantitative kind. Figures 3 and 4 will serve to indicate many others of a similar nature. In figure 5 is a view of the contact walls of these two rock formations as they existed in 1897. No face of any Trenton fragment here shown is the same as those seen in figure 3. In figure 5 a strong arched root is present in the upper left corner but no roots pass over the faces of the Trenton beds. In figure 3, however, a recent fall of Trenton fragments has revealed (at *b*) roots which, in their search for water and dissolved mineral matter had found a hidden fissure and occupied it. The wall which once protected them on the outside is gone. So too is the arched root of figure 5. If one will now examine the south or Chazy wall in figure 3 he will find some evidence of loss from portions that were in place when the photograph for plate 5 was taken, but *all* of the old smooth face is not lost. If one could recognize some feature of the south wall common to the two figures he would have additional testimony as to the rate of change.

To a student of the peculiar conditions which gave rise to Cliff Haven physiography another question will arise. Why is it that only bedrock of Trenton age is to be found for three and a half miles northerly, or along the shore from Cliff Haven to Plattsburg, while on going nearly three and a half miles southerly, or from the smooth, hard wall of the Haven bay recess to Valcour bay, only bedrock of Chazy age is to be found? The answer to this question will involve some geological knowledge of the utmost practical value—a knowledge that would have saved many residents of Clinton, Essex, and Warren counties from the loss of their savings through boring for oil where the geologic conditions are such that it could not possibly exist.

In the first place, the great Adirondack mass (*Adirondackia*) consists only of old crystalline rocks or those which have been subjected to tremendous pressure and great heat. Around this old land or at least on the north, east and south sides there existed the waters of an ancient sea and all along this sea margin wide sheets of sand were deposited which in places attained great thickness. Over 400 feet of these beds are exposed in Ausable chasm. The Morrisonville "oil well" penetrated rock of the same character to a depth of over 750 feet but did not reach the basal

beds of the formation. Very interesting exposures of this same rock are to be seen along the Saranac river for some 2 miles above and below Cadyville. Here the thickness has been estimated to be over 1000 feet. The downwarping of the basin of the old Potsdam sea continued and its shore lines near Plattsburg retreated south-westerly. In off-shore waters new beds containing much lime were deposited on the top of the former sand beds. These newer rocks are easily recognized by their lithologic and other characters and have been named the Beekmantown formation because of their interesting exposures in Beekmantown township. Professors Brainerd and Seeley of Middlebury College gave much study to this formation in the Champlain valley and estimated its thickness to be in the neighborhood of 1800 feet. Beds of this age are well exposed along the lake shore for about a mile and a half south of Valcour bay. At the end of Beekmantown time there seems to have been a local cessation of deposit. On its recommencement the deposits were of a markedly changed character and were laid down on a much modified surface of the Beekmantown formation. The new deposits were named for the town in which they were well exposed and first thoroughly studied, constituting the Chazy formation. These are the rocks that form the great Bluff Point mass. Their thickness, as measured on Valcour island, is close to 988 feet. Over the Chazy beds there were deposited in succession those of Lowville and Black River age and over the latter the rock beds known as Trenton.

It will be proper here to ask how we may distinguish rocks of Trenton age from those of Chazy age, and as the outcrops at Cliff Haven show very many of the interesting differences in these deposits, we will call attention to a few of them.

Many of the ancient builders of Babylonia inscribed their bricks or molded them in inscribed forms. Because they did so we may now determine the date of the laying of many ancient pavements and corner stones. So too the maker of the Trenton pavement stamped it with his own easily recognized seals, which are far more numerous and more wonderful in character than any inscriptions left by either Sargon or Nebuchadnezzar. Trenton seals in the form of exquisite brachiopod shells, bryozoa and other remains of denizens of an ancient inland sea, may be found in the first rock ledge outcropping on the lake shore just south of the Cliff Haven steamboat landing. The southernmost Trenton exposures are more barren of life forms but even here the writer has found the beautiful stems of "stone lilies" and the delicate frondlike forms of

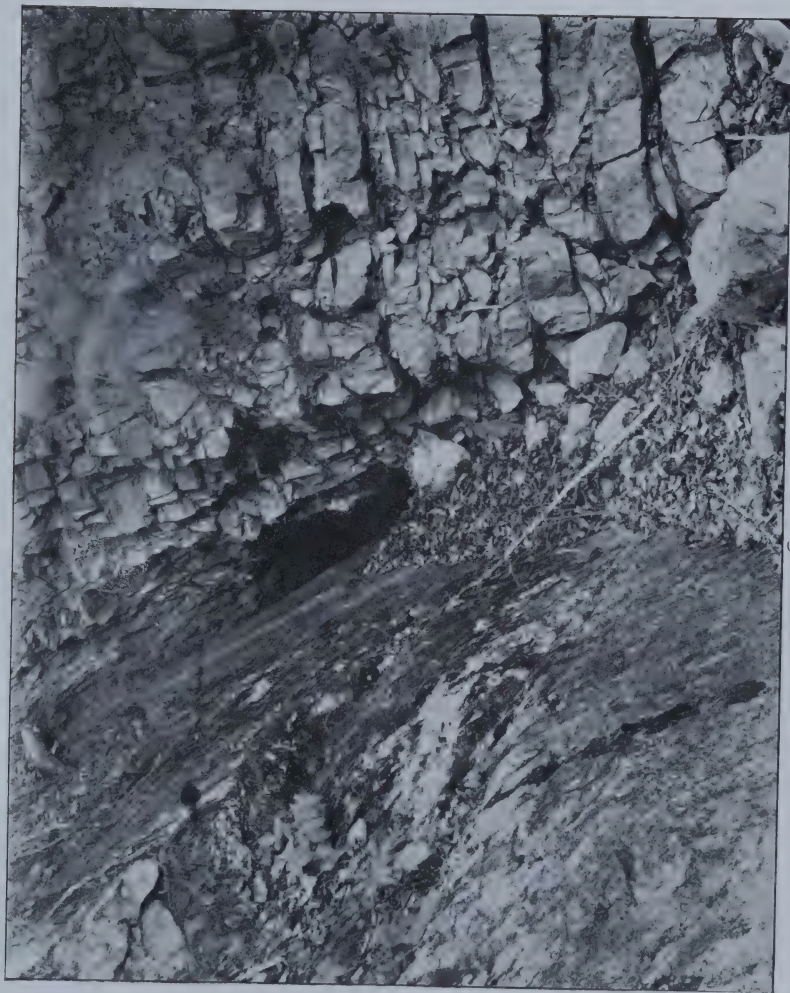


Fig. 5 View of fault at Cliff Haven. From a photograph taken by the author in 1897.

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graptolites. Nobody as yet knows the total thickness of the Trenton beds in the Champlain valley, but the exposures are very numerous and easy of access. A short row from Cliff Haven brings one to Crab island, and by automobile Cumberland head or Long point are quickly reached. These are all excellent localities for studying Trenton beds and for collecting from them. There is a fascination in the study of these ancient stamps or seals, but we shall not really appreciate their significance until we become familiar with at least some of the lessons they can teach. It is of importance that we notice one of these now.

Bulletin 92 of the United States National Museum is entitled "Bibliographic Index of American Ordovician and Silurian Fossils." It is a work of 1521 pages. On pages 1448 to 1452 a list is given of 524 different species of fossils found in and described from American beds of Chazy age. Following this is a list of 1080 different species found in the deposits of Trenton age. On comparing these long lists the student will be surprised to find that only 8 species are common to both groups of rocks. Some of the fossils in these lists are known to range through all the various beds of a single formation but there are others that are restricted to a single "zone" or to a series of thin sheets of deposit which together measure but a few feet in thickness. Knowing the short ranging species and their mutations one can identify the particular zone of any formation now exposed at the surface; and knowing how thick the formations are in any given locality, a geologist is able to tell the seeker for mineral wealth just what formations he would go through and the approximate thickness of each, if he should sink a shaft in any thoroughly studied locality. For instance, a boring made in the immediate vicinity of the Boston Cottage would pass through postglacial deposits and then enter the boulder clay of the glacial period. About 30 feet below the surface the Trenton rock would be encountered. As the local thickness of this formation is not yet known and as the particular zone exposed here has not yet been determined, it would not be possible to give the actual depth at which the Black River formation would be reached. The Black River limestone would, however, be the next formation encountered below and would have a thickness of less than 10 feet. Under this about 20 feet of Lowville rocks would be encountered and under these the Chazy would be found. The thickness of the latter formation would here be about 900 feet. After passing through the Chazy beds we would enter those of Beekmantown age and the sequence is known to still greater depths.

A little knowledge of this kind would have saved many a foolish investment not only in Clinton county but in many other quarters of the globe. We may now see one reason for the fostering of geological knowledge and, as the mineral wealth of the United States in its buried coal, oil, potash and metalliferous deposits is of enormous value, a more accurate knowledge of the earth's crust is much to be desired. At the same time we should bear in mind that there is a "growing army of nature students," of "men and women who love nature, or love science, for the sake of nature or science, without any set and immediate utilitarian purpose. . . . Mere addition to the sum of the interesting knowledge of nature is in itself a good thing; exactly as the writing of a beautiful poem, or the chiseling of a beautiful statue is a good thing."¹ To encourage such work in the geological field, museums should be established at all centers of learning. These could show the fossils, rocks and minerals of the surrounding region and if carefully and accurately labeled would in time become of inestimable value. Much is yet to be learned of the manner of rock formation and of the translation of the evidence of ancient conditions as recorded on millions of thin sheets of the earth's sediments. For the present, however, we must leave the interesting field of seals and sediments and ask a new question. If Trenton rocks naturally belong over those of Chazy age, how is it that we now find them placed side by side in the corner of Haven bay? We will return to that locality and give it further study.

As shown in figure 3, the Chazy wall has been ground down to yield a very smooth but somewhat scratched surface. Between the Chazy and the upturned edges of the Trenton beds is a thick sheet of rock flour. This is the grist formed by the grinding of the rock walls against each other. We have here a very instructive example of what geologists call a normal fault. The earth's crust, after the deposit of the Trenton beds, was here cracked open on a line running N. 79° E. How far to the west this crack or fissure extended we do not know, but easterly it reached Rockwell bay on South Hero and still further easterly separated Chazy beds on the north from Utica shales on the south. At Cliff Haven the north wall settled down, slipping bit by bit, a foot or so at a time, and probably giving the country in its vicinity a long-continued series of earthquake shocks. The amount of downward movement or displacement, when the top of the Black River beds had reached that

¹ Theodore Roosevelt, at the opening of the New York State Museum, December 29, 1916. See *Science*, N. S., 45:8-9.

zone of the Chazy which now shows here, had already amounted to 450 feet, and the total displacement is equal to this figure plus the distance from the base of the Trenton to the zone of that formation which now rests against the Chazy at this place. This will in time be determined, but a necessary factor in this determination will be the careful collecting and comparison of the fossils from all the exposed Trenton beds of the Champlain valley or from borings which may subsequently be undertaken in some portion of the region.

So far, this fault has had much to tell us, but we have as yet translated only a very small part of its story. If we carefully examine the *slickensided* Chazy wall we shall find that the scratches produced by the movement of the other wall against this do not dip to the north, as the Chazy wall itself does, but their lower ends are carried easterly. We must remember that the scratches we now see were among the last to be made for no doubt this "slate" was used many times and the older scratches removed by additional grinding. Here we state a new problem. If the last large movements of the Trenton were still downward then it also moved eastward at the same time. How may we account for such an eastward movement? The truth of the matter seems to be that we can not; and if we study the locality a little more closely we may find that, in its later movements over this wall, the Trenton moved *westward* and therefore *upward*.

Walking along the Trenton beds which are exposed for about one-half of a mile to the north of the steamboat landing, we shall note that their slope (*dip*, the geologists call it) is easterly. South of the steamboat landing we may notice a marked change in the direction of this dip and as we approach the exposure shown in figure 4 we shall find that the dip is decidedly westerly. The Chazy rocks on the south, however, dip easterly. If this condition of things continues westerly we should soon have the base of the Chazy resting against rocks well up on the Trenton side. In other words, our fault with a displacement of say 600 feet at the lake shore might have a displacement of a thousand feet where the railroad crosses it. This is evidently a rotatory fault, or at least it became such near the end of its activity. Now if we will face the Chazy wall we may see that the twist of the Trenton side must have been clockwise, which would indicate an upward and westward movement of its beds where exposed in Haven bay. The scratches would partake of the nature of broken arcs of great circles, the axis of rotation being situated at some deeply buried

point on a line perpendicular to the chords of these arcs. There is other evidence of an uplift of the east face of the Trenton where it lies near the fault plane, and this evidence we will now examine.

In figure 3 at *c*, *d*, *e* and *f*, there has been a strong upward bending of the Trenton beds just at the south of a clearly shown but minor fault plane. The beds at the right of this minor fault had their edges dragged down by the load which resisted the upward movement. At *g* and *h* still another minor fault plane is shown and the beds again have their edges dragged up on the south side. Near the northern end of this Trenton exposure the beds are again dragged up but here a little brook found an easy place in which to cross the barrier and it long since carried away all local trace of the fractured Trenton material. By taking a boat and going around the southern point of the bay we may note that the dip of the Chazy beds, near the fault plane, has also been altered by this local uplift.

If now we ask ourselves why late in the history of this fault the Trenton next it should have been lifted and tipped westerly we shall have to refer the movement to some period of great and extensive thrust from the east, such as that which existed during the Taconic or Appalachian revolutions. At these times mighty forces made themselves very manifest and threw many of the sediments of eastern North America into great folds. During these ancient, geologic revolutions old Adirondackia tried to play the part of a buffer state and remain neutral. When at last Vermont was conquered and compelled to join the attacking forces in the attempt to overrun New York territory she actually moved her boundaries from 10 to 30 miles westerly. The more solid Chazy rocks have shown less evidence of this revolution than the Trenton, which still plainly shows the effects of the ancient struggle.

The reader may perhaps say, "If there has been such a great dislocation of the rock foundations of Cliff Haven involving a downthrow on the north of, say 600 feet, why is it that the cliff at the south is not a sheer precipice now 600 feet high? If the Chazy on the north side of this fault is now covered by beds of the Lowville, Black River and Trenton formations, why do we not also find the same formations covering the whole Bluff Point or Chazy mass on the south?" These questions open the door to an interesting field of nature study.

So soon as any land mass is elevated it begins to feel the searching influence of the wind, and this robber not only carries away all the loose material that it can lift, but it uses this material to

grind against and detach other particles of the surface. Those who will consult the more recent textbooks of geology, or the gradually increasing literature on the work of wind, will find that there is here an important and almost virgin field for quantitative experimental work.

So soon as any land mass is elevated it has a decreased thickness of atmosphere over it, and this allows more energetic action of insolation and radiation. The more rapid the changes in surface temperatures, the more quickly the flaking off of rock surfaces is accomplished. This process, producing exfoliation, can be studied on all exposed and elevated rock faces in the Adirondack region.

Elevation also reduces temperature and increases rainfall. The two together lengthen the annual period in which the expansive power of freezing water can come into play.

Elevation not only increases the amount of precipitation but it increases the speed of running water and we here have one of the most effective agents for loosening and transporting rock material. Any textbook of geology will help one to attain some comprehension of how this and still other factors work and we need not burden our paper with the mere mention of numerous erosive processes which are intensified through elevation. It should be enough for us to know that every molecule of rock above sea level has its ticket purchased for the sea and, though frequent "stop overs" are granted, it *must* make its journey, though this may be by an air route, by running water, by moving ice, or by depression of great land masses.

If the fault at Haven bay began to develop so far back as Utica or Lorraine times, and while as yet both sides were under water and receiving deposits, then, as the southern side was lifted nearer water level, wave and current action would remove its unlithified surfaces and deposit them in the deeper waters over the northern side. When at last the higher side emerged from the sea its destruction would still further add material to the depressed side. If the faulting began after the emergence of Utica or Lorraine beds the lower side would also be subject to erosion but the higher side would be worn away the more rapidly.

To the reader it may seem that our attempt at an explanation has only increased his difficulty for we have implied that not only was the present Bluff Point surface once covered by beds of Upper Chazy, Lowville, Black River and Trenton ages (which together might measure some 1000 feet or more in thickness) but we have added thereto some 1500 to 2000 feet or more of Utica and

Lorraine beds. Our purpose, however, is not to explain, but to encourage those who like to exercise their mental powers, not only for their own advantage and pleasure, but to increase the sum total of human knowledge.

Much might be written about the Haven Bay fault but enough has been said to establish its peculiar value as an index of the vast changes which may be brought about by long-continued action of natural causes. The "Mills of God" may grind "slowly" but their action never ceases. After all it is not the spectacular that counts in the long run.

One of these days we shall be able to narrate fully the changes which took place in the Adirondacks and the Champlain valley after Lorraine times. At present we know that the carving which gave rise to our hills, valleys and plains was accomplished in part by sun, wind, frost, running water and the powerful action of thick ice sheets or glaciers moving southerly. The last of these, the Wisconsin ice sheet, brought many a rock specimen to Cliff Haven from the far north and these "boulders" are strewn in remarkable profusion along the lake shore from the bathing beach to the steamboat dock. Glaciated surfaces are still to be seen on some of the rock ledges on the road to Hotel Champlain and in figure 6 we present a view of a fresh surface just west of the road by the "bluff," which was cleaned off for quarrying purposes in 1915. This figure well shows the plaining effect of the moving ground moraine. A part of this moraine is still seen in contact with the stone just as it was left at the close of the glacial period.

As the ice barrier melted away at the north it allowed an invasion of the sea, called the Hochelagan sea, and wave action cleaned off many rock surfaces. Just before crossing the Little Ausable river on the road from Plattsburg to Peru one passes by a gravel pit which is part of a recent beach line and which contains many species of sea shells whose present home is along our North Atlantic coast. The elevation of this beach is about 200 feet above the present Lake Champlain surface. When the land had sufficiently recovered from the "depressing influence" of the great ice sheet to be able, through recoil, to lift this "Peru beach" above water, the waves of the Hochelagan sea still beat against the Bluff Point mass. When this sea surface had dropped to a level about 80 feet above that of Lake Champlain, wave action removed part of the ground moraine seen in figure 6, and the level sod-covered shelf in the upper right corner is a present witness of deeds of a dim past. At a still later date the receding waters began to cut a shelf



Fig. 6 Glaciated rock surface at Bluff Point quarries. At upper right a portion of the ground moraine is seen and its grass-covered surface shows the position of an ancient water level of the Hochelagan sea.

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in the weak Trenton beds near the Haven Bay fault. This ancient lake shelf is fairly well shown near the right edge of figure 2. Note that the present surface does not follow the slope of the bedding planes but cuts across their upturned edges. The strand line was then farther inland than now. When the lake was reduced to its present level it had to start near the outer point of the Chazy bluff and begin anew its carving of the Trenton.

In New York State Museum Bulletin 133, pages 159-63, will be found an article by the author dealing with evidence of a pre-glacial lake which he has named Lake Valcour. A still more ancient body of water worked long enough to cut the Trenton and other weak beds of the region down to a rather extensive local plane but it did not succeed in removing the harder Chazy mass now forming Bluff Point. The ice sheets of the glacial periods next began their grindings of Clinton county surfaces but they succeeded only in lowering Bluff Point from its more ancient domineering height and in rounding off its edges. These ice scourings, however, grooved the old wave-cut Trenton shelf and spoiled its flatness. This flatness the Hochelagan sea tried to restore by cutting down the hills of glacial deposits and using the removed material to fill up the hollows. Last of all a new brook system, draining into Lake Champlain, began to carve the region, but so far it has cut only rather narrow channels in the late sea bed. The general level of the country, which we first noticed, is due then to a sequence of causes involving ancient seas, glacial periods, and recent seas, all of which left traces of their work.

At different times during this elevated interval the rocks were in places cracked open to great depths, and these cracks were filled with molten lava. Two of these lava-filled fissures are to be seen at Cliff Haven. One of them is near the southern boundary of the Champlain Assembly grounds and is best seen from a boat. The lava filling this fissure proves, on analysis, to be like that first discovered by Bonet in the Monchique mountains of Portugal and is now known as Monchiquite. At another period in the history of this region the assembly grounds were again fissured, and this fissure filled with a very different lava called fourchite (from Fourche mountain, near Little Rock, Ark., where similar dikes are found). This fourchite is the only known dike of its kind in Clinton county and may be seen just north of the steamboat landing. It is 32 inches wide and runs about N. 95° W. or toward the extreme southern end of Crab island where a few displaced masses of it are still to be seen. This dike is also of unusual interest

because soon after it was filled, and before the central portion had become cold, the fissure walls sprang wider apart and a new filling rushed up from below. Before its arrival, however, and under the low pressure of the newly opened walls, the bubbles near the older lava surfaces expanded and by that expansion further chilled their walls. They thereby saved their bubbles from obliteration by the new filling. A view of this dike is given in figure 7.

There seems to be evidence that these fissures never reached the ancient surface of the land. This evidence will be given in a forthcoming paper on the "Geology of Valcour Island." If the conclusions there given are supported by further study, we may hold that after this dike was injected into its fissure, some 3000 feet thickness of deposits have been removed from over its present exposed portion. The dikes of the Champlain valley have not yet been given the attention they deserve.



Fig. 7 The fourchite dike at Cliff Haven

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SOME STRUCTURAL FEATURES OF A FOSSIL EMBRYO CRINOID¹

BY GEORGE H. HUDSON

(With 1 plate)

While recently engaged in the study of a specimen of the genus *Urasterella* I found, associated with it, what appeared to be an embryo crinoid. The structure of its arms and their branches, however, revealed no definitely formed ossicles but in their place there appeared to be a linear series of irregularly shaped transverse disks or semicircular wedges of developing stereom in an otherwise fleshy extension of epidermal or associated tissues. This structure was so like that of the spines and spinelets of *Urasterella medusa*, as revealed through gum mountings under cover-glass and photomicrographic stereograms (see plates 1, 2, 4, and 5 in article "On the Genus *Urasterella* with Description of a New Species" in the annual report for 1915 of the Director of Science) that for a long time I half suspected the specimen might be but a detached fragment of this sea star and its crinoidlike appearance to be due to an association of plates originally surrounding some body opening which was protected by a cluster of unusually long spines and connected with a tubular extension simulating a crinoidal column. Both plates and spinelike processes were fairly commensurate in size with those of the *Urasterella* next to which it lay (see upper part of figure 2 in stereogram illustrating this paper) and, if a crinoid, but two infrabasals, three basals, and two radials were to be seen and these, in part, in vertical section. A portion of the surface of the specimen had been removed by weathering but it appeared as if the sharp eye of the collector (Dr Charles D. Walcott) had noted the spinelike processes and cut along them with a knife to expose them to their tips. How carefully this was done is clearly revealed by figure 2.

After encouragement given by certain paleontologists, to whom I showed the stereograms, that I might trust my vision in this matter, and after seeing, on reexamination, a vertical line of zigzag sutures on the column, I finally exorcised the *Urasterella* ghost.

¹ Paper as read before the Paleontological Society, Albany, N. Y., December 28, 1916.

Two reasons have induced me to describe this embryonic form as a new species and give it the self-explanatory name of *Embryocrinus problematicus*. The first of these is because of the arm structure.

The gum process has enabled me so many times to reproduce sutures where others had long failed to detect them (as, for instance, in the anal and radial plates of *Palaeocrinus stratus*; see New York State Museum Bulletin 149, plate 6, figure 1, and in recent work on *Steganoblastus*) that I must place some confidence in its ability to show such structures where they really exist. These crinoid arms show no trace of them. In studying the stereogram here presented comparison should be made with the four plates already mentioned as accompanying Doctor Clarke's recent annual report. It is doubtless true that some of the white partings in our present illustration are due to cleavage planes in the calcite, but it must be noted that the plates of the theca show but few such planes and their white partings reveal true structural characters. It must also be noted that in the pedicellariae of *Urasterella medusa* the spines and spinlets actually broke up into disks on decay. If the interpretation of structure here given be correct, then primitive arms in crinoids developed, so far as their main ossicles were concerned, much as did spines, and from such a linear series of mixed disk-shaped and wedge-shaped ossifying centers either a uniserial or a biserial arm might be evolved. The factors determining the ultimate outcome would in large measure be due to the amount and kind of motion given this arm during its period of evolution.

The second reason for presenting this specimen to the public is because it forms so fine an example of light penetration made possible by mounting in a transparent medium and under a cover-glass, thus doing away with the surface scattering of light from the myriad points of an unpolished surface.

***Embryocrinus problematicus*, new genus and species**

Theca subconical, 0.75 mm wide at base, across basals 1.66 mm, height of cup 1.8 mm. Apparently four or five infrabasals, five basals and five still larger radials, two of which are clearly seen and one at the left carrying an arm is also apparently present. From radial to first fork of arms 2.5 to 2.8 mm. Column 0.6 mm wide, apparently of five series of plates, nine in 0.6 mm. These microscopic plates of the column are fairly well shown in the photo-

Fig. 1. x20

Fig. 2. x20



To be viewed through a stereoscope

Embryocrinus problematicus

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graphic stereograms though details may be lost in the process of reproducing as a halftone.

Covering both column, infrabasals and basals is a coating of epidermal structures which measures about 0.08 mm in thickness. The numerous white dots shown are sections of spines between 0.02 and 0.03 mm in diameter. Near the arms are cross-sections of biserial pinnules with cover-plates. One of these cross-sections is less than 0.03 mm in diameter.

Specimen collected by Dr C. D. Walcott from the Trenton near Trenton Falls, N. Y., and now in the Museum of Comparative Zoology, Cambridge, Mass. It was loaned the author through the courtesy of Dr P. E. Raymond and Hon. Samuel Henshaw.

If the pinnule fragments belong to the specimen, which is extremely probable, they serve to increase the difficulty of interpretation. In the most primitive cystids brachioles were no doubt associated directly with short food grooves. The extension of the food groove possibly never involved the turning of a brachiole into an arm. Epithecal extensions like those found in *Blastoidocrinus* and the blastids were never developed from arms which were once exothecal; the recumbent arms of *Malocystites* may have had their origin in free arms like those of *Canadacystis*. If brachioles developed before supporting arms and if the arm structure was afterward developed to form a common food conduit, enabling the bracholar structures to function at some distance from the mouth and also allowing a large increase in their number, then one of our difficulties disappears.

NOTES ON THE BANNER STONE, WITH SOME INQUIRIES AS TO ITS PURPOSE¹

BY ARTHUR C. PARKER, *Archeologist*

Among the many interesting objects of stone which the American Indian has left as a legacy to the archeologist, few appear more interesting than that which has been sometimes called the "banner stone." Objects of this character, with the gorget, the bird and boat-shaped stones, and a number of other forms, have been classed as "ceremonial objects."

The "banner stone" is peculiar to North America. Its range is approximately the United States east of the Mississippi valley, and southeastern Canada, (see figure 1). The material of which these objects are made varies greatly according to locality. They are, however, nearly always made from soft and easily worked stone, such as steatite, talc, pagodite, slate and marble. Some have been found, chiefly in southern New York and New England, made from bluestone and granite pecked into shape. These are not perforated, but have grooved sides. Most of the heavier granites have an incomplete perforation.

The forms of "banner stones" are many, some fantastic in the extreme and others severely plain and crude.

The principal classes are, first, those specimens having two thin, flattened wings extending in the same plane from a common centrum. This center may be socketed or it may be notched or grooved on either side. A comparison of these types is shown in plate 1.

The second form comprises the more solid varieties of the horn or "pick" shape and analogous forms. This class is represented in plate 2.

The third class consists of the one-armed or geniculate variety. This form is generally of a solid pattern and has a larger hole than the other forms. Unlike the cylindrical holes of all other drilled banner stones the geniculate form has an elliptical hole (see figure 1, plate 3). The elliptically socketed banner stone may or may not have an arm or "thumb." The form of this class suggests a closed fist, with or without the thumb held upright.

Banner stones belong to the period preceding and immediately following the era of the white man in America. They are found

¹A paper read before the July 1916 field meeting of Morgan Chapter, N. Y. S. A. A., held on the John Dann farm, Honeoye Falls.

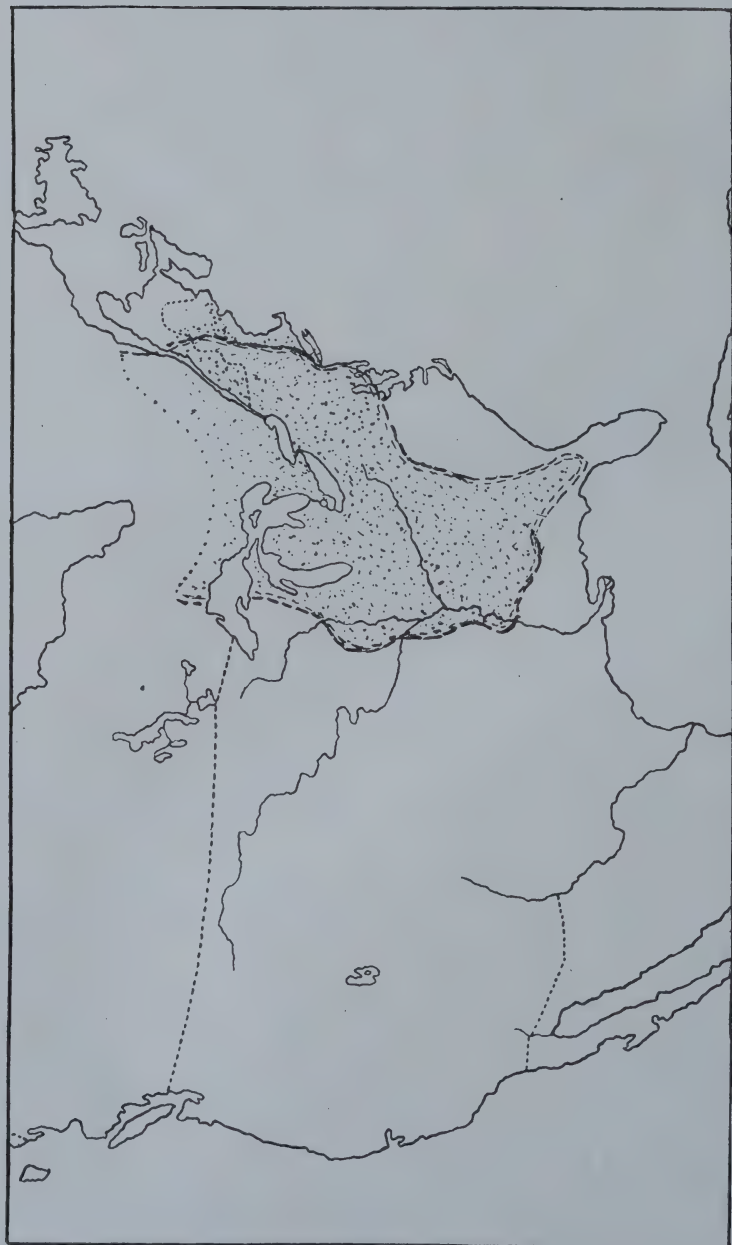


Fig. 1. Map showing the distribution of the banner-stone. These articles are found east of the Mississippi basin and southward into Florida. The northern range is the drainage basin of the Great Lakes and the St. Lawrence.

Plate I



Range of forms of banner-stones

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Plate 2



Range of types in New York State of the lunate form, sometimes called horn or pick-shaped

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throughout eastern North America and Canada on prehistoric village sites and in mounds. Mr E. P. Upham writes that of the approximately three hundred specimens in the National Museum, about one-half came from "mounds," a small number from village sites, and the remainder from ploughed fields or from the surface.

That banner stones should have been abandoned by the many tribes who used them, as they came in touch with the white invader, is significant. Does this not mean that they were given up because some more useful article was obtained from the white man? Certainly we know of several aboriginal utensils that became gradually obsolete with the coming of European goods. Or should we hold that banner stones were abandoned long before the coming of the European?

The varied forms in which the so-called banner stone is found suggest varied uses of this puzzling artifact. It seems probable that the pick or horned type, the thin-winged butterfly type and the elliptically pierced type may have been intended for distinct and separate purposes.

Banner Stones on Handles or Shafts

In many instances, by examination, it is found that the hole perforating the body of the banner stone tapers, as if for the insertion of a tapered rod. An examination of many broken specimens clearly indicates fracturing by internal pressure. Banner stones which have been made for experimental purposes and broken by internal pressure within the socket show fracture lines identical with those of ancient specimens. Thus, it seems reasonable to believe from the form of the stone and its perforation that banner stones were designed to be placed upon rods, spindles or shafts. By placing a banner stone upon a shaft and studying its poise and the use it suggests, we may arrive at some approximation of the actual purposes of the implement. In conducting our investigations, therefore, a thin-winged banner stone was placed on the rear end of a javelin shaft to see what effect this would produce. We found by experiment that an ordinary spear shaft headed with a sharpened flint does not fly with precision but rotates to a perceptible degree at the point of balance, causing both point and tail to describe circles, the circumference of which depends on the degree of rotation and the length of the shaft. Thus, a spear does not fly with absolute precision. To be of correct form for throwing,

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Plate 4



Showing method of using a pump drill with a bannerstone as a spindle whorl for perforating a slate tablet

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its use as a spindle whorl for fire-making and drilling. In our experiments¹ we used nearly every type of banner stone with equal success and all forms of drilling were used, including the pull string, strap, bow and pump. The thin-winged forms were especially efficient, the air resistance giving weight and steadiness to the rotating shaft. This is so apparent that a pump drill worked on a smooth surface, in conjunction with a banner stone used as a fly-wheel, keeps the shaft rotating upon one point (see plate 4).

The value of the banner stone used upon a spindle must have been apparent to the banner stone maker. A simple twist of the spindle would reveal its possibility as a whorl and with this discovery its use would be suggested. We can hardly see how the aborigine of the polished stone age who made banner stones could have neglected to employ the banner stone as our experiments suggest.

This subject leads us to inquire into the prototype of the banner stone and to discover the reason for its various forms. The wings of the artifact suggest in some ways the wings of a flying bird, other forms suggest the ears of an animal sewed together or winged seed pods, or winged insects, while still others plainly represent horns. The centrum, by its one grooved side, suggests an original tube of cane from which wings expanded. Our knowledge of the Indian's veneration for the thunder bird and indeed his regard for the assumed magical qualities of birds, suggests the possibility that the banner stone wings were the heavy portions of an effigy designed to represent a bird, which was fastened to the spindle or shaft. The horned type of banner stone might represent the horns of a buffalo or some mythical monster that was believed to emit fire or to symbolize power. The horned type of banner stone in a considerable number of specimens has upon the surface at the centrum certain cross-hatched or incised projections which suggest, to the writer at least, an attempt to represent horns laced, sewed or tied together. Any student of Indian mythology will quickly recall the many legends of horned monsters, especially serpents.

Among the uses of the banner stone heretofore suggested is the theory advanced by Frank H. Cushing, which describes the banner stone as used on the stem of a calumet to prevent it from tipping over when placed upon the ground. Within our experience, we have not seen banner stones associated closely with pipes, although platform pipes are sometimes found on the sites yielding banner

¹ Experiments conducted during December 1915 and January and July 1916.

stones. We have not learned, however, of a banner stone and pipe from a grave that would bear out this theory.

An interesting specimen in connection with this idea occurs in a highly decorated form of pipe in the New York State Museum collection. The pipe is of European brass. About the bowl of the pipe extending from the neck-base upward is a large crescent-shaped object perhaps intended to be a moon effigy or more remotely a canoe, though the crescent is too thin to resemble one closely. On one side of the crescent is a figure of a man with an arm extended and holding a shaft having a weighted bottom. The pattern has been cut out and riveted on the crescent. In form this adjunct to the pipe somewhat resembles a banner stone, but we do not believe that the maker of this pipe was ever familiar with banner stones or knew of their actual value. This pipe of brass, which



Fig. 2. Mound effigy of native copper. Note the wing-shaped ornament on the head. The people who made these embossed copper drawings used banner stones. Note the object held in the right hand.

Plate 5



Senecca pipe of brass thrust through a boat-shaped or lunate ornament of brass



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has a wooden core and stem, has an earlier prototype in certain forms of prehistoric Onondaga clay pipes, the bowl of which is extended forward and backward to resemble a canoe. (See plate 5).

Another use of the banner stone is that of a helmet ornament suggested by certain human figures embossed on sheet copper from a mound (see figure 2). There is some merit in this conjecture when a study is made of the elaborate head dresses of the mound-building period. The Sioux and other Indians within modern times have decorated their heads with horns and the Iroquois cap had a spool-shaped socket at the crown in which an upright feather was placed in such a manner that it would revolve.

The allusion to the fish tail shape of the banner stone made by Dr George Byron Gordon, curator of the University Museum, Philadelphia, is given further significance by the conclusions of Dr Clarence B. Moore in his reports¹ in the Journal of the Academy of Natural Sciences of Philadelphia, volume 16. The results of Doctor Moore's expedition along the Green river, Kentucky, were made remarkable by the numerous banner stones which he discovered in graves, especially on "Indian Knoll," Ohio county, Kentucky. Here the banner stones were found associated with heavy hooked implements of antler, called by Doctor Moore "net knitting needles." The winged stones are called "mesh spacers" and a considerable argument is given supporting the theory. This idea is new to most American archeologists but the theory has some merit. We are not convinced, however, that it is without difficulties nor that it is quite so apparent that one is warranted in giving a "use-name" to the object hitherto called "problematical."

Some observers have suggested that the "knitting needles" were *atlatls* or parts of them and used as auxilliary devices for projecting javelins. Doctor Moore argues that this supposed use would also necessitate explaining the reason of the close association of the "mesh spacer" banner stone with the hook. He presents a valid objection when he says that no points of antler or flint were found that could have been used as "tips" for the shaft and further says that the hooked antlers are too short for use as *atlatls*. We may not be convinced of this entirely in view of our experiments with the banner stone as a tail weight to a spear shaft.

It is interesting to note that banner stones have been found in considerable numbers during the past two years. We mention again the discoveries¹ of E. W. Hawkes and Ralph Linton in New

¹ Philadelphia, 1916.

Jersey, on Rancocas creek near Masonville. Here banner stones were actually found in caches associated with the lowest stratum in which artifacts were present.

Implements Suggesting the Banner Stone

In connection with our studies of the banner stone as a whorl we have examined the drill spindles of various races in several of the larger museums. We find that the headpiece of a drill spindle employed by the Eskimo, for example, resembles in certain ways the knobbed or blunt ended banner stone of the horned type. The headpieces are rather more neatly made than the remaining portion of the drill among the Eskimo. The Eskimo top pieces are

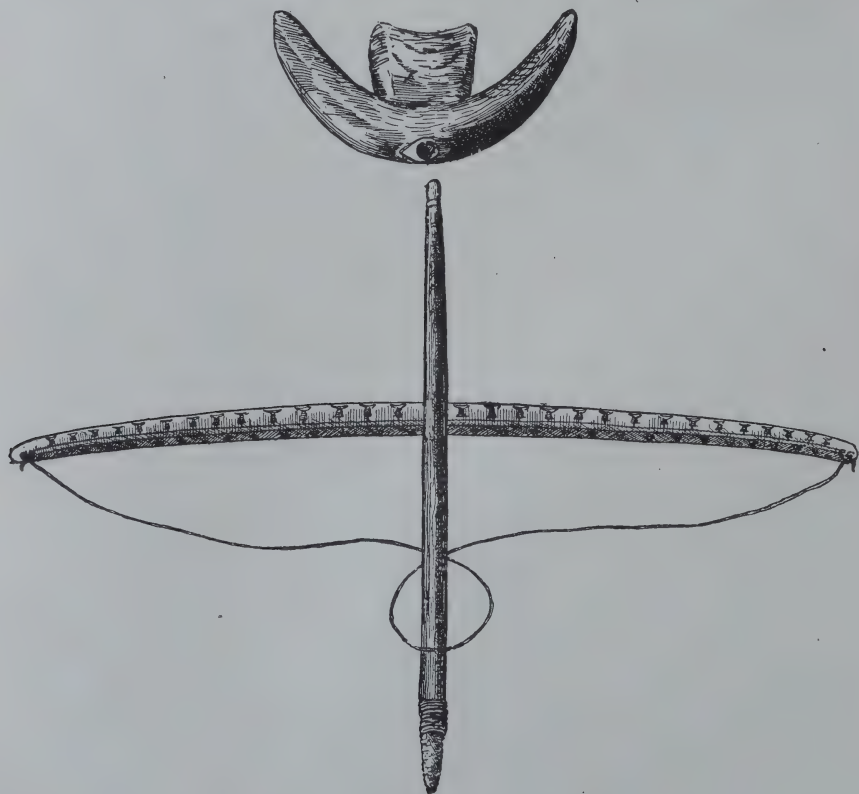


Fig. 3. Boring set used by the Point Barrow Eskimo. From Report National Museum, 1888, Hough. The top or mouthpiece resembles one form of the banner stone.

¹ A pre-Lenape site in New Jersey. Anthropological Publications, Pennsylvania University Museum, vol. 6, no. 3.

frequently carved of bone and have at their upper portion, that curve to fit the mouth, wooden projections which are used as handles and held in the teeth. On the lower side is the socket in which the top of the spindle is inserted. One of these headpieces worn through by long use and pushed down over the shaft would quickly suggest a new use. The possibility of wearing through is not remote because the holes were drilled in the bone to a considerable distance in order to prevent the slipping out of the spindle. Indeed, to prevent the rapid wearing into the bone or ivory the Eskimo even recently mortised into the headpiece small pieces of rectangular stone into which the hole was drilled. Not all headpieces take a similar form and there is a large individual variation. In general, however, the headpiece was curved upward so as to fit against the mouth, which gives a crescent or boat shape to many specimens.

The utility of such an object as a whorl, once discovered, would bring about many further variations and new outline motives would be employed. Dr George Byron Gordon in his study of banner stones¹ suggests that certain forms were derived by the lines suggested by a whale's tail and we see no reason why this idea should not seem plausible though tails of other aquatic creatures may have been likewise copied.

Our conclusion is that the banner stone is a portion of a more complex utensil or ornament and was designed to be placed upon a shaft or spindle. The manner in which this was done and the purpose is suggested by the experiments described. We can by no means be certain that any of these suggested uses were employed, but likewise we can not positively say that none of them are valid, especially in the face of the presumptive evidence we have advanced.

Notes on the Process of Manufacture

In the New York State Museum collections are some score of banner stones in the process of manufacture. We are able through an examination of these articles (specimens of which are found in almost every stage of the process of manufacture from the crude block of intermediate form to the finely polished specimen) to describe in a measure the various stages in the making of banner stones. The unfinished forms are usually not of slate, which was easily worked and quickly finished, but of compact shale, schist, sandstone or granite. The material out of which this series is made is tough rock not easily worked or perforated.

¹ Museum Journal, U. of P., June 1916.

The first process, after a suitable material had been found, was to chip the implement into shape, outlining the wings and centrum. With the exception of the central bulb from which the wings expand and the indentation on the upward curve, all these heavier specimens in form are kidney or bean shaped. The second process as indicated by our series was that of picking or pitting; the third process that of scouring or grinding, and the fourth finishing the polish. A set of these specimens also indicates that the hole or perforation was started in the centrum on the inward-curving side. Preparations for the perforation were also indicated on specimens which have merely been blocked out, by a picked-in indentation. It would seem, therefore, that the shaft which we postulate was placed in the centrum was inserted first at this point. It may be possible that the shaft was sometimes placed in the unfinished specimen.

Incomplete banner stones have been found throughout the State from Lake Champlain region on the north to Staten Island on the south and westward through the Mohawk valley to Chautauqua county (see figure 2, plate 3). Other specimens are reported from the St Lawrence valley, but a greater majority have been reported from the Finger Lake region of central New York and from the valley of the Genesee and its tributaries.

A fine incomplete specimen of laminated limestone containing chert is contained in the D. F. Thompson collection (T-27923) and was found at Waterford near the Mohawk river. This specimen has been roughly chipped to shape and shows some minor picking. The top side is indented to shorten the length of the centrum, but the perforating process has not been started.

An unfinished specimen chipped and roughly picked to form comes from the Susquehanna region a little east of Binghamton. It is a heavy specimen of compact schist containing a vein of sandy quartz. The centrum has been roughly blocked to shape, but there is no indication that the specimen had been sufficiently formed for the commencement of drilling. The material out of which this artifact is blocked appears entirely unsuited for the purpose and very likely this specimen was rejected in the unfinished form because of the defects in the material. This specimen is 6 inches in length and the measurement through the centrum diametrically is $2\frac{1}{4}$ inches and the weight is $28\frac{3}{4}$ ounces.

Another specimen of unfinished banner stone is of silicious sandstone. It has been picked completely to shape but one wing is longer than the other by nearly one-half of an inch. A chip,

however, has been taken off from the longer point and if the specimen had been abraded to eliminate this chip it would have been fairly symmetrical. The centrum is well formed but on one side the central line is not correctly opposed to that of the other side. A most interesting feature is that the wings are placed at an opposite slant as if each had been grasped in the hand, the upper and shorter one being twisted to the right and the lower to the left, somewhat after the fashion of propeller blades. No attempt has been made to start a perforation. This specimen is from Schoharie county, but no detailed location is mentioned in the catalog.

Specimen C-25045 is composed of picked mica schist and has well-defined wings, though they are somewhat thick. The socket is well outlined on either side and the perforation has been indicated both at the top and bottom by slight concavities picked in. The drilling process has not yet started and there is no indication of surface polishing. This specimen is from site no. 38, explored by Mr Fred H. Crofoot.

A broken specimen similar in the stage of process was found by Mr Forest Ryder at Coxsackie, N. Y. The material seems to be decomposed granite. The centrum is well defined and on either side has been flattened in order that perforation may be started. The specimen is not polished, but still bears the marks of the abrading process. (Mus. 32871).

Specimen C-21154 is a heavy bulbous and bilobate banner stone from the Abel farm in the Genesee valley and was found by Mr Fred H. Crofoot. Like all specimens of unfinished banner stones in the State Museum, this one is drilled in the central portion, at the wider portion of the stone. The perforation continues nearly half the depth of the stone and is exceedingly smooth. It appears not to be a tubular drill hole. There is a depression on the under side, but no drilling has been attempted there. A portion of the surface of the stone has been polished and it is thought that the specimen was intended to be used approximately in its present form. The weight is 26 ounces.

A very fine specimen of picked sandstone banner stone of incomplete form was collected by Prof. D. F. Thompson at Hoosick Falls, N. Y. (T-29792). The centrum is especially large at the upcurved end and probably the picking process has not been completed. The specimen shows no signs of polishing, but a perforation nine-sixteenths of an inch in diameter has been started, the broken portion of the drill core being visible at the bottom of the

perforation which is about seven-sixteenths of an inch in depth. The weight of this stone is $16\frac{1}{4}$ ounces. The wings are not uniform in length, there being a difference of more than one-fourth of an inch in length. The twist of the wings, right and left, is also apparent in this specimen.

A narrower specimen of unfinished banner stone (M-2419) was found at Arius lake, Rensselaer county. The specimen is $6\frac{1}{4}$ inches in length and weighs $15\frac{1}{2}$ ounces, the width through the centrum being $1\frac{1}{4}$ inches. The perforation has been started and the drill core projects from the drilling, which is about three-sixteenths of an inch in depth. There is a groove on the upper or outer side of the specimen which appears to have been slightly polished, but the general surface of the stone has been scoured only enough to remove the deeper pitting. One of the lower corners has a chip taken out which shows the material to be an impure marble quartz.

A fine specimen of unfinished sandstone banner stone from Atwood, Perth county, Ontario, Canada, is in the Museum collection and is interesting for the purpose of comparison. A twist in the wings of this specimen is also evident. The bulbous centrum is flattened on each side and drilling has proceeded about two-thirds the diametrical length of the centrum. A broken core shows as a break at the bottom.

Specimen M-21591 is an unfinished granite banner stone with the drilling at the expanded portion and carried to the depth of about three-eighths of an inch. This specimen shows drilling by tubular perforation. The indented and in-sloping top of the stone has a rather high polish, but the under side has been only roughly picked and ground into shape, though there is an indentation in which the perforation was to be made.

A very interesting specimen of a dark drab slate banner stone (Y-29632) comes from the Hudson valley in Orange county. This specimen has been undoubtedly finished, though the perforation is only about one-half the depth of the centrum. The centrum is like a pipe bowl, fifteen-sixteenths of an inch in diameter. The lower curve of this centrum is about three-eighths of an inch from the curvilinear line forming the outward circumference of the specimen, but a notch has been cut in the base of the wings meeting the bottom of the bowl like centrum. It is not exactly in the center, which makes the wings appear unequal in length by almost one-fourth of an inch. Two tally marks appear at the top of each wing.

CONTRIBUTIONS TO THE PALEONTOLOGY OF NEW YORK

DEVONIAN GLASS SPONGES

BY JOHN M. CLARKE

I The Ontogeny of *Hydnoceras*

(Plate 1)

The interesting specimen here illustrated was recently sent to the State Museum by Mr L. D. Shoemaker of Elmira. It is a slab of sandy flagstone found near the village of Wellsburg, N. Y., 6 miles southeast of Elmira. One surface of this slab carries, as represented, two essentially entire and mature individuals of *Hydnoceras*, undoubtedly of an undescribed species, which lie side by side as they must have stood when they were growing erect on the sea bottom. The specimen is otherwise rather full of fossils characteristic of the Chemung fauna, principal among which is the little brachiopod *Ambocoelia gregaria*.

The genus *Hydnoceras* has been abundantly described and it would seem as though almost every variety of expression is manifested in the various species represented in the Monograph on the Fossil Reticulate Sponges.¹ In the preparation of that somewhat exhaustive treatise, very abundant material was available, and in the study of the representatives of this nodose and highly specialized genus *Hydnoceras*, it was desirable, at times to emphasize local variations in form and character of surface which might not have been so distinguished had the specimens been found in the same place or colony. In other words, it became very evident in the study of the various local colonies of this genus of sponges, in some of which the individuals grew by hundreds and thousands, that there was in many cases a distinct local impress which probably, on careful weighing of the evidence, would be found not to equal species values.

We there also indicated that morphologically, the simplest type of expression in these sponges is the obconical, smooth tube or reticulum; that is a skeleton without any division into nodes, rings, tufts or other surface modifications. This type is maintained in the greatest abundance throughout the climacteric development of these

¹ Hall, James & Clarke, J. M., 1898.

glass sponges in the Chemung fauna, and the genus *Dictyospongia*, which expresses it, is not only freely developed in species but its individuals are often of commanding size and graceful form.

It was also indicated in the study of these fossils that the smooth, obconical shape being primitive, the nodose structures of the surface appeared as a secondary character. Such evidence, however, was not, at the time of the preparation of the work cited, regarded as altogether conclusive.

It was further observed in connection with the study of the interrelations of these sponges, that the large series of annulated forms known as *Ceratodictya* stood in somewhat similar relationships ontogenetically to the smooth cones, as did the nodose species; that is to say, the secondary conformation of the surface begins to express itself either as nodes, or as rings, or as a combination of both together. We must here note a third consideration, and that is the series of prismatic or banana-shaped sponges, *Prismodictya*; a large tribe of very effective, compact and graceful appearance, in which the prismatic sides are developed with rarely any indication of nodosity or annulation. These prismatic sponges also, are found to develop their prismatic faces as a secondary feature, the incipient part of the sponge or its infantile condition being still of the smooth, obconical pattern.

We have then three different secondary modifications superimposed upon the primary expression of these sponges, all of which, in combination or independently, are competent to produce and have produced a very extraordinary variety of generic and specific expressions. The exact order of succession in these features should be established, if this is possible. Inspection of a very large amount of material does positively indicate the development of the prismatic form of the skeleton before the appearance of either rings or nodes, and of the other two it is reasonably safe to say in a general way, that the tendency to nodes manifests itself earlier than the transverse constrictions which produce the annulations. The normal order of time and succession therefore, in the development of these three characteristics from the simple, smooth obcone, is first the prisms, second the nodes, third the rings. In terms of this ontogenetic succession it is therefore possible to estimate any species of these various types of the prismatic, nodose and ringed *Dictyosponges* and their combinations, in terms of stationary, arrested, or accelerated development referable to the standard type of the simple, smooth skeleton.

These ontogenetic traits are brought out emphatically and beautifully in the specimens now under consideration. Here is a very strongly nodose and a very deeply annulate species in which the slightly modified, early and infantile expression of growth is continued for a long period, the lower obcones being smooth or faintly prismatic. In one of these this infantile condition is maintained for fully half the length of the completed skeleton, while in the other it covers a less proportion — one-third of the full length of the sponge. Thereupon follows, at the upper end of the obcone, the primary development into nodes, and directly thereafter, the constrictions which are to produce the annulations. Over these annulations, constrictions and nodes run the prism lines in the usual manner characteristic of all the nodose species of this genus *Hydnoceras*.

The smaller of the two specimens under consideration (that at the left of the drawing) is actually complete so far as its length is concerned and the distal or upper extremity is the entire margin of the osculum of the sponge itself. The specimen presents other features of maturity and decline which are highly instructive. The first three of the annulations, counting from the bottom, are broad, their nodes are blunt; but therewith onward the constrictions become deeper, the annulations narrower and sharper, the nodes relatively smaller. The gradual decline in the prominence of the nodes is obvious, and in the seventh and eighth rings the nodes show distinct signs of suppression; in the eighth or terminal ring a suppression which indicates a tendency to complete extinction in further growth, had such further growth continued. This condition is likewise true of the rings themselves, and accompanying all this general decline after the adult development of the skeleton midway of its length, is its loss of diameter, approximating again in this respect the infantile condition. The specimen thus quite emphatically and unusually shows the unfolding of the general morphological characters of the genus and species in regular order through the nepionic stages into the mature, and then their equally gradual decline from the mature ontogeny into the gerontic or senile stage.

This evidence thus ties together a good many outstanding scattering data, regarding the structure of these sponges and the true relations of their individual development. The special interest of this specimen is that it helps to interpret the morphologic value of the sponges of this class; that is to say, here is a sponge, obviously

of the genus *Hydnoceras*, which bears in itself the characters of the typical genera; *Dictyospongia*, the smooth sponges; *Prismodictya*, the prismatic sponges; and *Ceratodictya*, the annulated sponges; and upon these characters assumed in succession, are imposed the nodes which, generally speaking, are later than the other features (although they may appear at times on the prism-angles without the intervention or presence of the annulations); all of which indicates the fact that the nodose sponges of this type are the extreme terminus, the final term of development along these lines. They are the most advanced, the most highly accelerated, the most extravagant in ornament, and carry most conspicuously in themselves the evidence of the path they have followed in their development. Whether or not the nodose sponges are the last to survive in this peculiar group is quite another matter; upon that we are not prepared to speak positively. They are certainly the most abundant of all the known representatives of the stock, but logically the last to survive would be the stronger type, and theoretically the stronger type is the simplest.

The species under consideration has no outstanding specific name. It can not be brought into specific relationship with any other form now described, and for this reason it is herewith given the designation, *Hydnoceras walcotti*, in honor of the distinguished secretary of the Smithsonian Institution.

2 Chemung Sponges from the Vicinity of Erie, Pa.

Through the courtesy of Mr E. J. Armstrong of Erie, Pa., I have received interesting indications of heretofore undescribed species of *Dictyosponges* from the neighborhood of his city. Both of the species are represented by more than one specimen, and each is of very exceptional interest as presenting a type of structure, broader than specific, which has not heretofore been recognized from the great sponge fauna of the later Devonian Period.

The first of these may be designated and described as:

CERATODICTYA ORYX sp. nov.

(Plate 2)

The term *Ceratodictya* was introduced by Hall and Clarke for the purpose of embracing a series of rather commanding species characterized by simple or duplicate annulations but without retaining either the prismatic or the nodose features of the surface.

Ceratodictya, in its ontogeny, may properly be construed as elementary rather than senile; that is to say, the constrictions of the surface do not, in the ontogeny of the sponge, appear to be preceded by any other conformation of the skeleton.

The specimens in hand are long, slender, twiglike skeletons, with very prominent horizontal rings, all of which, in the best preserved of the two examples, appear to be duplicate on the periphery; that is to say, these rings stand out prominently and abruptly; they are compressed, and the surface is grooved in such a way medially, as to make each ring a duplicate one. On the second and longer specimen this duplication is not obvious, or at least is no more than suggested, but the preservation of this individual is bad and the absence of the crown groove may be due entirely to this fact. These annulations are separated by smooth and subcylindrical surfaces, which are rather long, as they have fully twice the width of the annulations themselves, and this is rather more than the interval in the other species of the genus. As preserved, the specimens show a sinuous or gracefully curved stock or twig, very slender and scarcely tapering from one end to the other, so that the original sponge must have been of extraordinary length in proportion to its diameter. The shortest specimen measures 100 mm, and carries 12 annulations; the longer specimen is 180 mm, and carries 23 more or less recognizable annulations. The average diameter of the shorter and better preserved specimen is 15 mm.

The matrix of this specimen is Chemung sandstone of somewhat coarse grain, and no trace is left of the reticulum. The larger specimen is buried in the sand, but the smaller is represented only by an external mold. The block which carries this smaller specimen has also a very indistinct trace of either another individual or the continuation of the first, bent at a very sharp angle. The locality of these specimens is given by Mr Armstrong as "about 6 miles southeast of Erie, Pa."

HYDNOCERINA gen. nov.

It seems necessary, for purposes of reasonably precise definition, to introduce a new generic term here for species of these sponges which combine the characters of *Hydnoceras* and *Ceratodictya* in such a way that they can be safely referred to neither. I think the group which is represented by the species herewith described, must be looked upon as a departure from the normal development of the elementary types of these sponges. The variability in their

expression and the easy flexibility in the development or suppression of their surface characters, may make the group a convenient receptacle, even though the characters can not be very strictly delimited. Hydnocerina, then, is characterized by a reticulum bearing more or less prominent rings crested by one, two or even three rows of nodes, the nodes being often of irregular size; sometimes long and simple, sometimes low and duplicate, frequently fusing together and thus losing their distinctness.

HYDNO CERINA ARMSTRONGI sp. nov.

(Plates 3 and 5)

This species is represented by two specimens which present a fairly complete conception of the entire reticulum, the larger being almost the entire horn; the smaller, the initial end of a specimen which might well have been of the same dimensions as the larger. The aspect of the initial part of the reticulum is interesting as displaying very clearly the development of the exterior features. Prism-faces are almost wholly undeveloped, although suggested; annulations appear at once and these are quite simple. This small specimen carries six of these annulations, on the summit of which, at the crossing of the prism-lines, are intimations of nodes. At once thereafter, apparently, the nodes spring into greater prominence and the annulations at first become more upstanding through deeper constriction of the intervals. Growth appears to have been regular for a matter of three or four additional annulations, the nodes developing in such fashion that up to this point the species would be safely placed with the genus Hydnoceras. Then commence the irregularities which take it outside the boundaries of that genus. The annulations become broader, grooved on top; the nodes appear first small and then large, or small and large together, some of the rings being made up of a single row of large nodes as below, and other rings being broad, duplicate, or triplicate, grooved, with the nodes quite low and confluent. The larger of the specimens shows eleven annulations in which the character of the nodosity may be indicated from below upward as follows:

- 1 Large and simple
- 2 Large, some of the nodes fused laterally
- 3 Large, some of the nodes fused laterally
- 4 Double row of low nodes

- 5 Single row of low nodes
- 6 Triple row of low nodes, more or less fused vertically
- 7 Large, simple nodes, obviously fused vertically
- 8 Large, simple nodes
- 9 Low, triple, grooved nodes
- 10 Low, triple, grooved nodes
- 11 Low, duplicate, grooved nodes

The above details give a fairly adequate account of the characters of the species. The length of the specimen is 180 mm, and this length, if increased by the length of the smaller specimen, with a slight allowance for the break, would be 220 mm. The specific name is given as a recognition of Mr Armstrong's interest and his diligence in the study of the paleontology of his neighborhood. These specimens are from "about 8 miles east of Erie, Pa."

ELUCIDATION OF THE GENUS *CRYPTODICTYA*

(Plate 4)

In the Monograph of the Dictyosponges its authors described as *Cryptodictya alleni*, certain frond-shaped structures of large size which seemed to have been sponge masses with extremely thin, expanded reticulum and which, in being tossed together by the waves, had assumed irregularly infolded shapes. There was no evidence, from the study of these bodies, that the films had ever been inclosed into vases or other symmetrical forms. The sponge character of these organic structures was only presumptive, but their association in the Chemung rocks of Cattaraugus county, N. Y., was with other sponges and the occasional indications which they presented, of structures which might be interpreted as spicular, and also the fact that surfaces were irregularly marked by little monticules or acute papillae, sometimes symmetrical but often elongated and irregular elevated surfaces which might have served as bases for spicular tufts and did indeed, when protruding into the matrix, seem to be accompanied by evidences of such spicular sponges.

Mr Armstrong has recently discovered a series of small disks which have the same general surface appearance as those of *C. alleni*, but which are distinctly outlined, and I have little hesitancy in comparing the latter with the type species of the genus. These smaller disks are all of about the same size and average about

2 inches in diameter; are approximately circular, with some irregularities in outline, and the upper surface is broadly convex. Many of them show the effects of compression in a rifting of the surface, and so we are obliged to infer that these biscuit-shaped bodies were originally nearly as convex as the bell of a jelly fish. The surface is marked by monticules or acute elevations, distributed with apparent irregularity and varying very much in number. There are some in which these conicles are hardly apparent; others may have ten or twelve, while still others twice this number. In the slab which Mr Armstrong has sent me, there are at least eleven individuals, and he speaks of there having been more in the rock from which these were taken. The accompanying illustrations will elucidate the character of these specimens better than any further description, but it may be added that there is no clearly defined indication of spicular structure on these surfaces; further, that the surfaces of the organism must have been very thin, for the space between the outer and under casts is tenuous. Several of the specimens show the peculiarity of a scar or a broken, disordered spot at or about the center of the convexity, but as this is not shown by all, it does not now seem possible to regard this as a structural feature.

Whatever may have been the full form of these sponge bodies, there seems no evidence now that they were attached to the bottom by any other means than their spreading growth or by the margins of their reticulum. No specimen shows any evidence of an upright or vertical stem or other form of support. As the species is very sharply defined from *C. alleni* and occurs in a different horizon, it is here distinguished by the name *Cryptodictya tylea*. Mr Armstrong reports that his specimens were found loose in the gorge of Six Mile creek, 7 miles east of Erie, Pa., and he is of the opinion that they must have come from something less than one hundred feet above the base of the Chemung.

3 A Branching Form of Silicious Sponge

This sponge expresses a peculiar type of growth so unusual to this reticulate group that its silicious character may be held in some degree of reserve. The quadrate skeleton structure, however, seems to be evident on various parts of the surface, and the probability is that in the predominant silicious character of the great sponge fauna

of the Upper Devonian period, this species partakes of the nature of the rest.

The specimens on which the genus and species are founded occur in a slab of hard silicious Chemung sandstone found loose at Hinsdale, Cattaraugus county, N. Y., and sent to the Museum by John S. Johnston of Wellsville. On the weathered surface of this slab is the deep impression of the large, branched specimen, (plate 6), taken as the type of the genus and species. In the substance of the slab several others, smaller in size, have been found preserved as external and internal casts.

OZOSPONGIA gen. nov.

Ozosporgia johnstoni sp. nov.

(Plates 5 and 6)

Obconic, anodose, nonprismatic; generally expanding from the base up and rather abruptly constricted to well-defined ostia; extended below into short or long, subcylindrical stems which join at various intervals, uniting in or branching from a common stalk. This stalk or stem tapers so slowly that it must at times have reached very considerable length. The best expression of this compound form is shown in the typical colony, where it will be observed that two individuals divide the common stem equally, the branching stems having about the same caliber as the parent. One of these sponge cups has grown to larger size than the other, and from the stem of the lesser has apparently branched off a third cup attached by a much shorter stalk. The true position of this third individual may quite possibly be concealed by the compression of the colony. Over the surface of these bodies, particularly about the base and stems, there is a perfectly evident cross-lining, indicating a network, but the greater part of the surface bears irregular, low ridges running longitudinally and in some measure evidently due to lateral compression, though some such roughened surface might well be quite normal to the sponge.

The other specimens here shown indicate variations from this individual expression. Figure 2 shows a young offshoot of small size, branching from the parent cup by a very short stem. In these specimens the network of the reticulum is much more clearly indicated. The stem here does not terminate so abruptly as indicated,

but is further represented by a stain in the rock. It is not thought that this structure can be construed as a basal spicular tuft.

Figure 1 is a single individual broken at the basal end but indicating an extending stem, while figure 3 is the basal end and very much compressed stalk of another individual.

EXPLANATION OF PLATES

· **Plate 1**

[187]

Hydnoceras walcotti sp. nov.

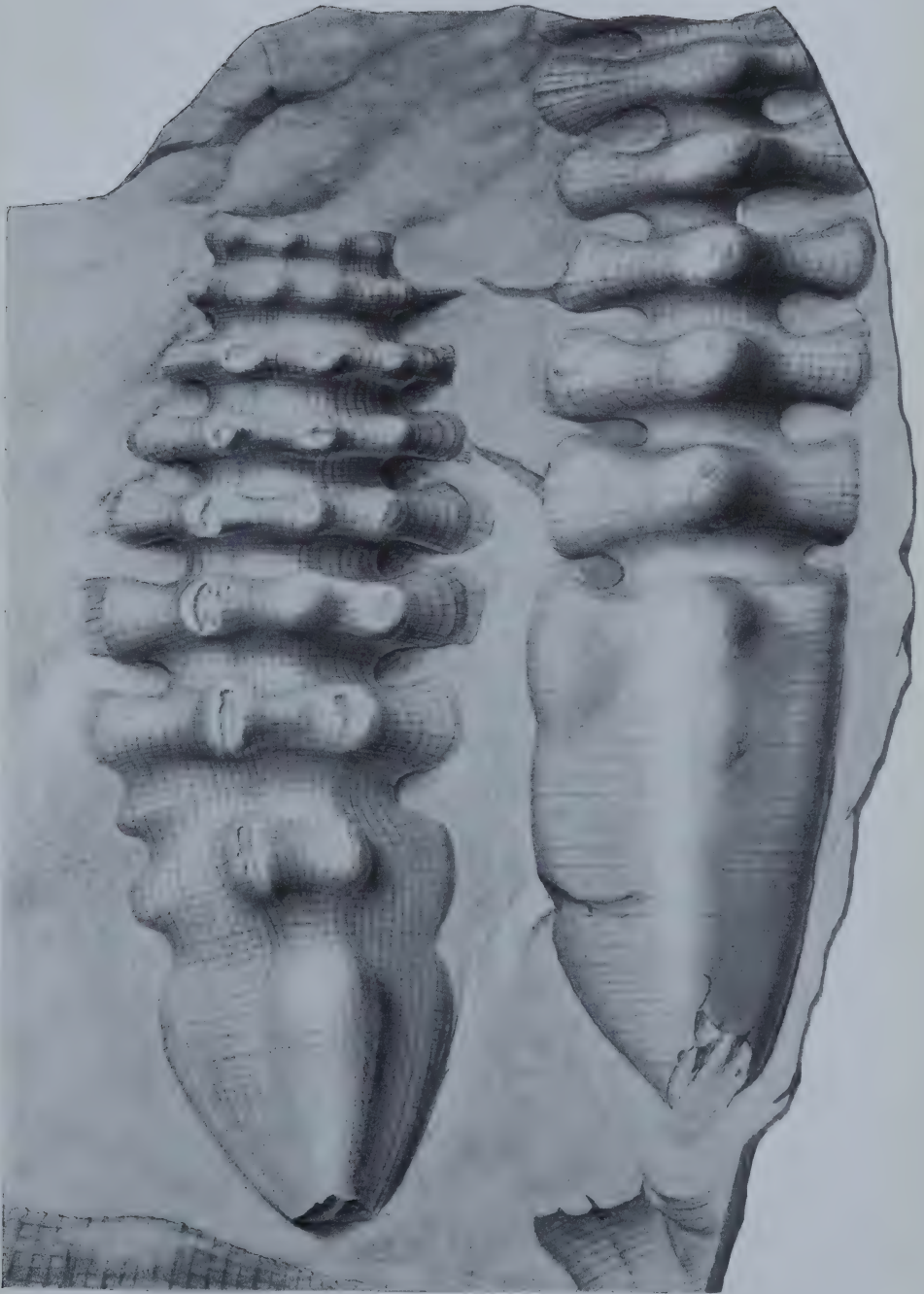
(Page 180)

The original specimen; two individuals lie side by side as they may have grown on the sea bottom. The drawing has been made from a plaster counterpart of the original natural mold.

Chemung group near Wellsburg, N. Y.

[188]

Plate 1



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Plate 2

[189]

Ceratodictya oryx sp. nov.

(Page 180)

Figure 1. The shorter but better preserved specimen of this genus, showing the grooved annulations which are generally characteristic of *Ceratodictya*.

Figure 2. The longer of the specimens, but poorly preserved.
Both are casts from natural molds.

Chemung group, 6 miles southeast of Erie, Pa.

Plate 2



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Plate 3

191]

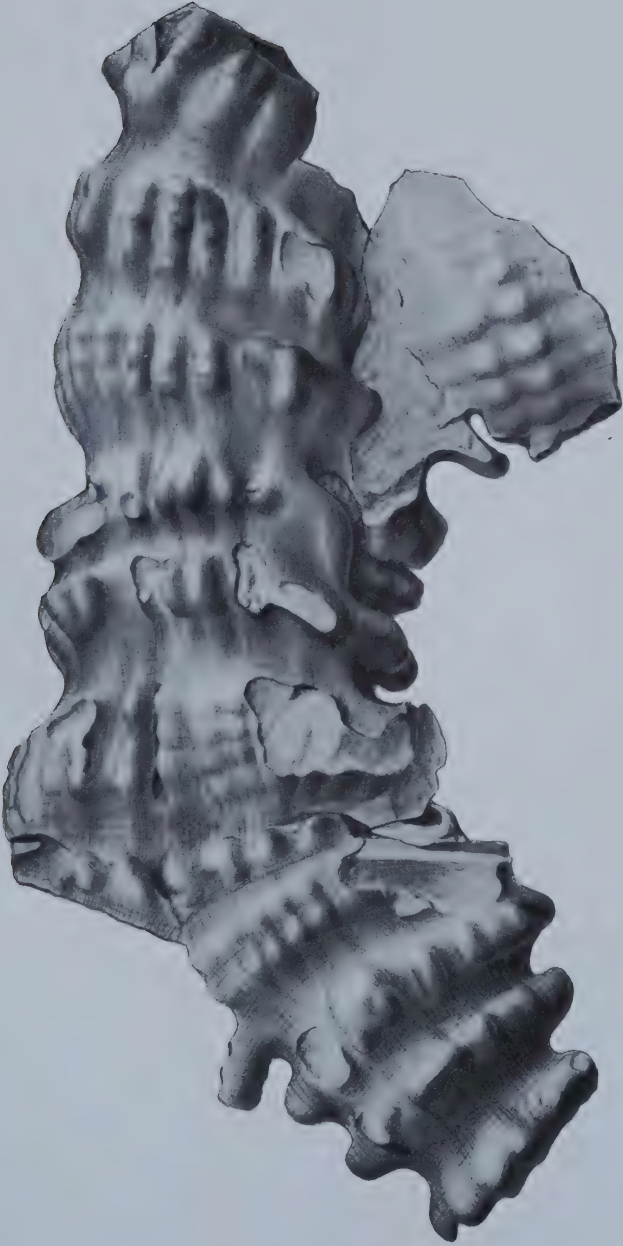
Hydnocerina armstrongi sp. nov.

(Page 182)

This is the best preserved of the specimens and shows the characteristic variation in the nodes upon the annulations.

[192]

Plate 3



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Plate 4

[193]

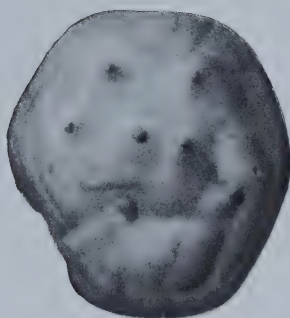
Cryptodictya tylea sp. nov.

(Page 184)

Figures 1-5. This plate shows a series of these discoid sponge bodies as they occur somewhat flattened in the sandy shales of the Chemung group in the gorge of Six Mile creek, 7 miles east of Erie, Pa.

Plate 4

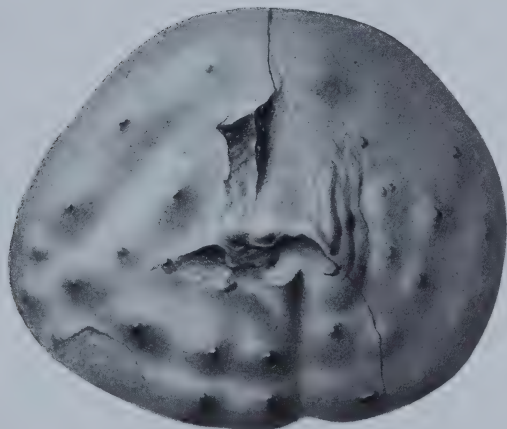
1



2



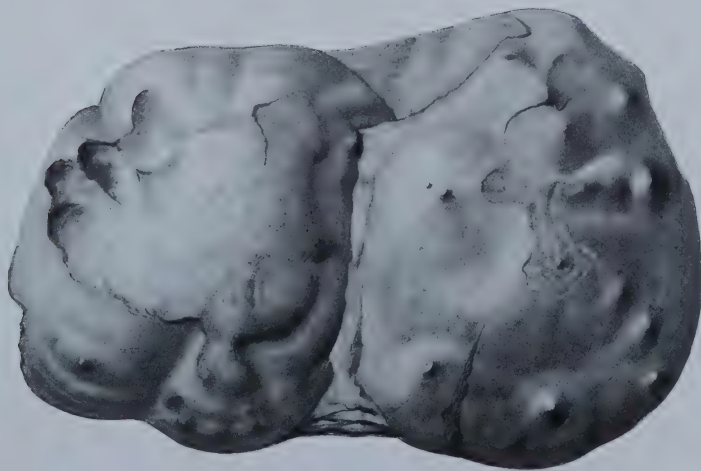
3



4



5



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Plate 5

1951

Ozospongia johnstoni sp. nov.

(Page 185)

Figure 1. A small single obcone of this species.

Figure 2. A specimen showing a single branching cone from the parent frond.

Figure 3. The base of an obcone retaining a part of the stem or pedicel.

Hydnocerina armstrongi sp. nov.

(Page 182)

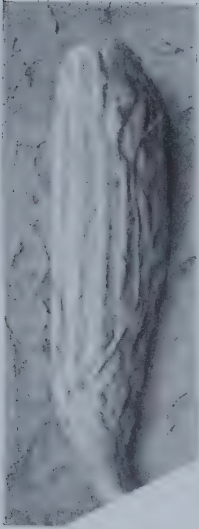
Figures 4 and 5. Opposite sides of the initial end of the individual which shows the incipient development of the nodes upon the rings.

Chemung group, 8 miles east of Erie, Pa.

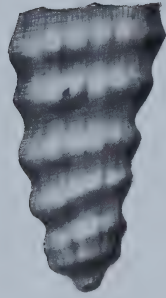
[196]

Plate 5

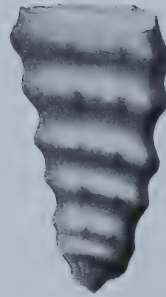
1



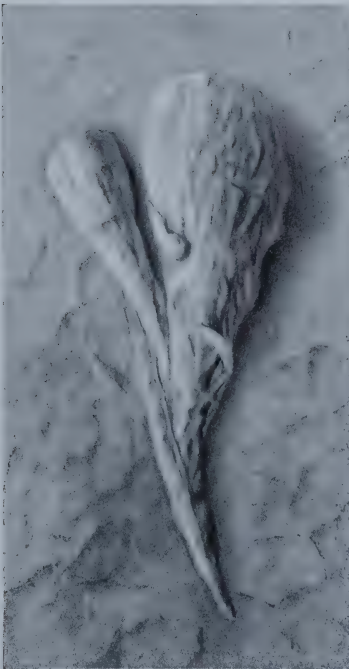
4



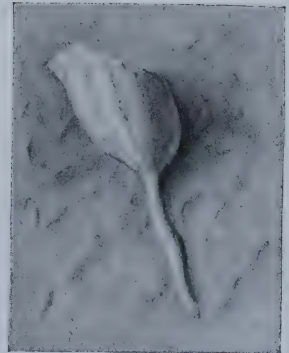
5



2



3



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Plate 6

[197]

Ozospongia johnstoni sp. nov.

(Page 185)

The branching colony on which the description of the genus and species are based. This appears to represent three individuals or obcones derived from the same pedicel. All of the figures of this species have been made from plaster replicas of natural molds in the Chemung sandstone at Hinsdale, N. Y.

[198]

Plate 6



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STRAND AND UNDERTOW MARKINGS OF UPPER DEVONIAN TIME AS INDICATIONS OF THE PREVAILING CLIMATE

BY JOHN M. CLARKE

The most conspicuous features on the surfaces of the sandy strata of the Portage group in the Upper Devonian of New York, are markings which have commonly been assigned to the moving of the waters over the strand. Wherever the beds of this important formational term of the Devonian become preponderantly sandy, these phenomena are observable. They have long been known; indeed, while they have commanded very little attention in the literature, and have been generally passed over as almost self-explanatory, the best outstanding descriptions of them are those given by the first official geologist reporting upon the region where these developments are most manifest. Reference is made to the descriptions of them given by James Hall, in the *Geology of the Fourth District of New York*, 1843, pages 232-37. These and the very striking illustrations he presented of them, have passed current as final, and even though occasionally his figures have been reproduced, there has been, so far as the writer knows, no published modification of his explanation of their origin.

During the many years which have elapsed since the date of that report, and especially since the writer's attention has been particularly directed to the phenomena, mechanical and biological, of the Portage formation, there has grown up in the Museum a very extensive collection representing the various expressions of these strand phenomena, from the study of which it has become perfectly obvious that we have not had a proper understanding of their origin. It is thought that the present paper may suggest a truer conception of them.

Preliminary observations. The phenomena which we have to discuss or to debate, are conformations in strong relief, invariably on the under side of the strata as they lie in normal position. The beds which bear these surface figures are slabs and flags of thin, hard sandstone; in other words, flagstones in which lamination beds are obvious but cleavage only potentially developed. In every case, also, the relief figures on these slabs in normal position fit into corresponding grooves and depressions in the underlying and intervening sandy shales. Emphasis is here to be laid upon the expression

sandy shales, for when the shales are predominantly of clay, no such marks seem to have been made.¹ This is a fact and an observation which is in accordance with the interesting propositions recently set forth by Kindle,² who finds that the muddy bottom or muddy shore in which the sand is not predominant, is not competent to take such current marks as the commonly known ripple marks. The phenomena under consideration are not invariably those which can be interpreted by any action of moving water alone, so far as known to the writer, and it is necessary, therefore, to supplement the previous condition by stating that the shales of the Portage formation are prevailingly sandy, and in the upper measures of this formation, wherein these phenomena are most conspicuously shown, are quite inevitably sandy and therefore competent to take and preserve impressions that have been made by water in motion.

As a preliminary necessary to the understanding of this paper, reference is made at once to the accompanying illustrations. An effort has been here made to present these strand surfaces in their normal position and therefore counterparts in plaster of paris have been photographed to place alongside the pictures of the original rock specimens. If the observer's eye is quick to grasp these contrasting reliefs and intaglios, part and counterpart will help to remove risk from deceptive appearances. I say deceptive appearances, because even Professor Hall, in pointing out the fact that these marked sandstones occur with their relief surfaces downward in the strata, nevertheless so far forgot his statement as to illustrate one of the commonest varieties as a "cast of flowing mud," and such "mud flows" have been repeatedly referred to by geologists, as though their convex relief were the true one. "Mud flows" are in reality the natural casts of deeply marked strand slopes rilled and eddied by the ebbing tide.

In order, now, to present practically all the outstanding data regarding the particular phenomena with which we have to deal, I shall first quote from Professor Hall's very lucid description.

Casts of Mud Furrows and Striae

I have applied this term to certain appearances upon the under side of the strata of sandstone, or flagstones, which are numerous and extensive in the

¹ Markings similar to some of those here noticed occur in great variety in other rock media and in many formations. Notice is incidentally taken here in the illustrations of such records on certain Silurian argillaceous limestones.

² E. M. Kindle. Recent and Fossil Ripple-mark. Mus. Bul. 25, p. 4. Canada Geological Surv. 1917.

fourth district, as well as elsewhere in this group; having from my own observation detected them in other parts of New York, in Pennsylvania, Ohio, and even to some extent in Indiana.

These casts are elevated lines or ridges upon the surface of the stone, varying from the size of the usual scratches upon the present surface of the strata to the diameter of half an inch, and even one, two and three inches, and in one case I have seen a specimen six inches in diameter.

The only assignable cause for these ridges is the action of a current flowing over the surface of the strata, sometimes transporting sand and at other times coarser materials, which furrowed the surface upon which the subsequent deposits were made. They are, in all cases, preserved upon the under surfaces of sandstone or shaly sandstone layers, which rest upon soft shale, so that the furrows or scratches must have been made in this mud. They are not all confined to one position, but appear at different depths in the group; showing that the cause, be it what it may, operated through a long period, and in a pretty uniform manner. The ridges are never curved or bent on one side; and though two systems are sometimes observed crossing each other, they are still as well defined and their course as unbroken as in the glacial or alluvial scratches upon the surface of the present rocky strata.

From the frequent occurrence of these, and their continuation through a great thickness of strata, we can hardly suppose the furrows to have been made upon hard surfaces; and if we suppose the mud in which they were made to have been soft, it seems almost impossible to conceive how they should be preserved. Still the numerous similar facts in other rocks prove that even the most delicate markings are preserved, under even more unfavorable circumstances. The tracks of birds and reptiles in the New Red sandstone, with the impression of rain drops, is equally difficult to comprehend, were it not demonstrated beyond all question. Again it has been shown that in the Medina sandstone¹ the delicate wave lines and the minute ridges of sand, piled up before some little obstacle in the current, are preserved with the same integrity as they appear upon a sandy beach just left to dry by the receding tide. In the same manner, the evidence of these slight scratches and deeper furrows in the mud of the Portage group have been preserved in the casts formed by the succeeding depositions. Nothing can be more clear and convincing than the proofs, and nothing more beautifully illustrative of the effects of oceanic currents upon the bottom. We have little space here to describe these phenomena, and they should be seen to be fully appreciated. This fact, however, may be added to the number, if we have not already sufficient, to prove the condition of the sea in these remote periods.

The following woodcut represents a surface where three systems of ridges appear, or where the grooves were made in three directions.

This account is wise and safe; indeed may well be regarded competent so far as it goes. This phrase in the quotation may be emphasized, "they should be seen to be fully appreciated" — a characterization which in part justifies and leads to the present presentation.

¹ Pages 52 and 54 of the Geology of the Fourth District of New York.

Professor Hall in the above gave special attention to the remarkable casts of ridges and striae, and the specimen of these which he chose for his illustration is of such fine quality that the figure is here reproduced. It is no wonder that he compared them to glacial scratches upon subsoil rock surfaces, and little wonder, either, that later observers have looked somewhat suspiciously upon these scored



and grooved slabs as remarkably suggestive of ice work. In a paragraph directly following that quoted, Hall mentioned the fact that in two instances he had noted the direction of these ridges and found that it was nearly east and west. He also calls attention to the fact, which one occasionally sees, of the ragged surface of the furrow which was due, he intimates, to a tremulous motion in the body making it; just as one finds not infrequently among the glacial grooves. Furthermore, Professor Hall distinctly states his belief

that he had detected on the same sandstone stratum in outcrops twenty miles apart, striations that ran in the same direction and suggested to him a uniform cause efficient over this entire stretch of strand or sea bottom. I regret very much not being able to verify so important an intimation. "Thus it appears," says Hall, "that, whatever may have been the cause, it operated very uniformly over large surfaces."

It is important for me to premise, in seeking the interpretation of these phenomena, that, in my experience, ripple marks in the Portage strata are of rather rare association with these other strand marks. If this statement is even approximately true, then the rhythmic factors producing ripple marks are measurably excluded from the formation of the strand marks under consideration. Doctor Kindle's perspicacious and faithful analysis of the causes to which ripple marks are due, finds, as we have intimated, that whether laid under water or under air, a sandy medium is essential; that ripple marks are of two kinds, symmetrical and asymmetrical; that the former are due wholly to oscillatory action of the water and occur, in his conclusion, entirely in fresh-water deposits, that is, in water bodies presumably free of tidal currents; while the other or asymmetrical type characterizes the salt water ripples. Disturbance in the currents, interfering waves or tidal flows, obstructions to regular flow, projections of rocky points between sandy beaches and over seething bottoms, are all influential in modifying the form of the ripple ridge and furrow, and the amplitude of the sand wave is in a definite though not determined relation to the force of the tidal ebb. Therefore, in the opinion of Doctor Kindle, which has been supported by the observations of others, principally those of Dr G. K. Gilbert, the ripple mark may be of any reasonable amplitude, often attaining a width of many feet.

The objects which we have under direct consideration, divide themselves into two groups; those which seem readily to explain themselves and those which obviously do not.

To the former we may reckon the characteristic "mud flows," as shown on our plates 7-14. These, it will be observed, are obviously the markings made by rills following the fall of the tide, or possibly the retreat of heavy storm waves on a strand of low pitch. These phenomena have various expressions and are often accompanied by collateral contemporary markings showing the dragging, scratching or otherwise indenting of the surface, presumably by objects dragged down by the ebb and following the

same general direction as the surface rills. Tidal rills are produced by the downrush of considerable masses of water lagging behind the retreating and broken surge, and it is easily conceivable that larger amounts or continuous sheets of water, flowing down the strand, might produce series of unbroken water channels, rather than discontinuous rill channels. This is put forward as a possible explanation of the latter phenomenon, and as these and allied appearances seem to be intelligible by such explanations, they are included among those which are readily and deductively interpreted.

The other class of these strand markings includes those we are especially trying to interpret. Of this large class there are first the striated surfaces, which are here illustrated by specimens which are really less effective than that given by Professor Hall, but at the same time of more variant character. Various observers, speaking casually, have thought that these markings might have been due, in some part at least, to more or less compressed trunks of wood buried in the sand and fossilized. One might see a reason for such suggestions upon consulting our plates 16-19, but in my judgment this interpretation is absolutely excluded. There is seldom any straight tree-tissue associated with these beach marks, and whenever the opinion referred to has been expressed, it has generally been based upon the contemplation of the wrong side of the specimen. These slabs are actually grooved and furrowed in parallel lines, and these groovings are of various degrees of magnitude, from coarse to exceedingly fine. The surfaces of the larger grooves are not only sometimes, but usually striated finely by lines parallel to them. Even in our greatly reduced figures these details are very obvious and the fact stands out without reasonable challenge that these markings have been made by the dragging or shoving of irregular objects over the surface of the wet sand; not necessarily above water, but if not, then within the moderate water depths. One can conceive, for example, a heavy kelp attached at its root to a stone loosened from its moorings, thrown upon the strand and dragged down by the suck of the undertow, producing if moving with sufficient rapidity and without interruption, some such channelings as are indicated on our plate 16, or on plate 18, which is a single deep, sharply angular groove. But my observation leads me to doubt if anyone ever saw such an effect produced by the suggested cause. We may, however, for the moment, assume that heavy objects dragged by the undertow of storm waves might create such channeled strand and substrand surfaces as are here indicated.

Granting that the whole class of these parallel channelings and striations are of the mechanical origin suggested, I must say that my experience and observation do not justify the interpretation suggested above. I must therefore briefly refer to my field of observation in order to verify the conclusion which I am, by elimination, forced to reach with reference to these markings, and also to leave room specifically, for the wider or different experience of others in the observation of strand phenomena. In order to find some reasonable interpretation for these Devonian strand marks, many different kinds of coast have come under my examination — the broad and sandy shores and dune strands of bays and gulfs; mud flats a mile or more across, exposed and covered with every change in the tide; the short, steep, gravelly strands of rocky promontory fronts; capes and bays, retreats and endroits where the tidal interval may be slight or the tide waves rush in upon the coast like an army of white horses; tide-swept channels and broad, flat seabars of the islands, covering scores of square miles, among whose sands the sea breaks its way by inlets and gullies. I believe my experience has been variant and illuminating, much of it coming from intimate examination along several hundred miles of coast line on the shores and the islands of the Gulf of St Lawrence. I should remark further, that in this Gulf of St Lawrence region the tides are, as a rule, heavy; and heavy tides on strands of sharp angle would have the power, the other conditions being favorable, of producing such strand markings as those under discussion, if such markings could have been made this way. I am not convinced, either from my observation or from the considerable literature which I have been able to consult on the present action of the tides, that these things could have had the indicated origin under the action of such tides as exist today. It may be granted that heavier tides with more powerful undertow might have produced some of these effects. No such tides are now effective or at least no such tidal effects are, so far as observation and reading indicate, recorded. The world's tides may, it has been strongly contended, have been heavier in such ancient ages of the earth and so herein may lie a partial, in at least an alternative explanation of these channeled strands.

Let us now pass to the consideration of the so-called *Fucoides graphica*, the object early illustrated under this name by Vanuxem and by Hall, and which has long been known as eminently characteristic of these sandy Upper Devonian slabs, but whose vegetable nature was never contended for even at the time the name was

applied to it. These things are short, straight, rodlike relief figures usually single but often crossed and in radiating fascies. They are large and small and lie at all angles with reference to the slope of the strand or of the bottom. If they are accompanied by parallel channelings or grooves, the "Fucoides" may lie between them or even upon them at every angle. They therefore can have nothing to do with any tidal flow or other mechanical movement of the waters which would have the power to arrange loose material lying on the bottom or on the beach. I have troubled a great many of my colleagues by asking of them an opinion as to the nature of these objects, and I have profited very much by a suggestion made to me by Prof. J. B. Woodworth. Professor Woodworth has intimated that these rodlike grooves might well have been produced at the bottom of the shallow water through the formation of ground ice; that the rods, independently or in mass, crossing and radiating, are directly comparable to ground-ice formation, and as a result of further study of ground-ice phenomena, I am confirmed in my belief that his intimations are sound. If this is a fair deduction, we may be confronted here with preliminary proof of seasonal or climatic freezing in the Portage ocean. The inference is confirmed by the character of the longitudinal strand channelings. The presence of ice and the moving of shore ice along the strand, its shoving up or its dragging down, are clearly indicated by these phenomena and may well be called upon and account for all the parallel striated surface to which we have referred, and very particularly to that illustrated on plates 21 and 22, where two striated grooves lie in the mud, commingled with the crystals of ground-ice.

The competency of ground or anchor-ice to produce such rodlike crystallizations, would seem reasonably evident from the discussions which have been given by various authors, and I shall take this occasion to quote somewhat from the volume by Doctor Barnes on "Ice Formation," with special reference to anchor-ice and frazil.¹ This spicular ice, in the opinion of not only the author cited but of other writers, forms at the bottom under varying physical conditions, and the fact that it may vary in respect to the size of the crystals or crystal groups formed, is emphasized at various points in this work. It is frankly to be admitted that no writer has had occasion to record observations on this spicular structure in which the crystallizing rods attain the size that are indicated for *Fucoides*, usually the spicules being fine and massed together in anchor-ice

¹ John Wiley & Sons, New York. 1906.

in spongy condition. Doctor Barnes cites remarks made by Sir William Dawson from his observations on the formation of such ice needles in the St Lawrence and elsewhere:

The spicular ice may further grow on the bottom in the manner in which crystalline needles form in some saturated saline solutions. The fact that it forms most readily in open water, without any covering of ice, and in clear cold weather, indicates that radiation from the bottom has an important influence in its formation, but where the water is sufficiently cold it may crystallize on any nucleus presented to it, and more especially, it would seem, on metallic bodies and stones which are good conductors of heat. Hind states that on the coast of Newfoundland anchor-ice forms in large masses in the sea at depths of 60 or 70 feet, and it has been known to raise stones and anchors from the bottom and to freeze round fish caught in nets. These are merely desultory observations from the point of view of a geologist, but they may serve to show that there are different kinds of spicular ice and that they may be formed in various ways. It seems certain that several of these modes of formation are concerned in the production of the spicular ice so troublesome in our river, so that it is not prudent to limit ourselves merely to one theory of formation any farther than the general principle that they all depend on the same rapid crystallization of water under circumstances in which it tends to form groups of spicular crystals rather than solid sheets.

The suggestions above given can not be regarded as conclusive of the ice crystal character of *Fucoides*, for they deal with objects of different magnitudes. Professor Woodworth, in his study of the Boston clay beds, has illustrated crystallizations of ice lying between the laminae of the clay, such frost marks as one might expect on surfaces where a small amount of moisture has been free to take on crystal form under proper conditions of cold. Such occurrences are frequently observed.¹

While then the ice origin of these markings may not be conclusive in itself, these suggestive similarities to ground-ice and spicular bundles of ice crystallization, corroborated by the other evidences here brought together of the work of the ice upon these ancient strands, give good reason for the deduction that all these phenomena together are to be referred to the glacial conditions of the Portage sea.

As a corroboration of the foregoing interpretation, there is an interesting reference to the grooving action of the ice foot when well loaded with stones, in the account of the travels of Lyell in North America on his first visit, 1841-42. This is referred to because at

¹ The Glacial Brick of Rhode Island and Southeastern Massachusetts, by N. S. Shaler., J. B. Woodworth and C. F. Marbut. 17th Annual Report, Director U. S. Geological Survey, 1896, p. 951.

the time Mr Lyell was here, he and his colleagues were struggling for an interpretation of what were then commonly known as "glacial" phenomena; but the glacier itself, as a factor in producing such phenomena, had not yet arrived. Both Lyell and Hall used the word "glacial" in their writings with reference simply to the action of ice, and in most every application thereof at this time, to the action of moving berg or floe ice carried southward over the surface of the continent. Mr Lyell was always searching the beaches for an evidence of rock grooving caused by the movement of such ice, and on this first trip it was not until he had practically made his entire tour, that he happened to find what he sought on the rock beds of the beach at Cape Blomidon, Nova Scotia. I quote his memorandum regarding this occurrence¹ without reproducing his illustrations and for the purpose of indicating here the effectiveness of such a grinding by the ice, not only of such soft beaches as we have been considering, but even on the rocky slopes of the strand:

As I was strolling along the beach at the base of these basaltic cliffs, collecting minerals, and occasionally recent shells at low tide, I stopped short at the sight of an unexpected phenomenon. The solitary inhabitant of a desert island could scarcely have been more started by a human footprint in the sand, than I was on beholding some recent furrows on a ledge of sandstone under my feet, the exact counterpart of those grooves of ancient date which I have so often described in this work, and attributed to glacial action. After having searched in vain at Quebec for such indications of a modern date, I had despaired of witnessing any in this part of the world. I was now satisfied that, whatever might be their origin, those before me were quite recent.

The inferior beds of soft sandstone, which are exposed at low water at the base of the cliff at Cape Blomidon, form a broad ledge of bare rock, to the surface of which no sea weed or barnacles can attach themselves, as the stone is always wearing away slowly by the continual passage of sand and gravel, washed over it from the talus of fallen fragments, which lies at the foot of the cliff on the beach above. The slow but constant undermining of the perpendicular cliff forming this promontory, round which the powerful currents caused by the tide sweep backwards and forwards with prodigious velocity, must satisfy every geologist that the denudation by which the ledge in question has been exposed to view is of modern date. Whether the rocks forming the cliff extended so far as the points [indicated] 10, 50, or 100 years' ago, I have no means of estimating; but the exact date and rate of destruction are immaterial. On this recently formed ledge, I saw several straight furrows half an inch broad, some of them very nearly parallel, others diverging, the direction being N. 35° E., or corresponding to that of the shore at this point. After walking about a quarter of a mile, I found

¹ Charles Lyell. *Travels in North America*, 2: 144. 1845.

another set of similar furrows, having the same general direction within 5 degrees; and I made up my mind that if these grooves could not be referred to the modern instrumentality of ice, it would throw no small doubt on the glacial hypothesis. When I asked my guide, a peasant of the neighborhood, whether he had ever seen much ice on the spot where we stood, the heat was so excessive (for we were in the latitude of the south of France, 45° N.) that I seemed to be putting a strange question. He replied that in the preceding winter of 1841 he had seen the ice, in spite of the tide, which ran at the rate of 10 miles an hour, extending in one uninterrupted mass from the shore where we stood to the opposite coast at Parrsborough, and that the icy blocks, heaped on each other, and frozen together or "packed," at the foot of Cape Blomidon, were often 15 feet thick, and were pushed along when the tide rose, over the sandstone ledges. He also stated that fragments of the "black stone" which fell from the summit of the cliff, a pile of which lay at its base, were often frozen into the ice, and moved along with it. I then examined these fallen blocks of amygdaloid scattered round me, and observed in them numerous geodes coated with quartz crystals. I have no doubt that the hardness of these gravers, firmly fixed in masses of ice, which, although only 15 feet thick, are often of considerable horizontal extent, have furnished sufficient pressure and mechanical power to groove the ledge of soft sandstone.

In Nova Scotia the term "loaded ice" is in common use for large sheets of ice several acres in area, which are sometimes floated off from the rivers as the tide rises, with sedge and other salt-marsh plants frozen into their lower surfaces; also with mud adhering plentifully to their roots. In our speculations, therefore, on the carrying power of ice, we ought always to remember that, besides gravel and large fragments of rock, it transports with it the finest mud.

Doctor Harding informed me that the surface of mudbanks along the estuaries near Wolfville are often furrowed with long, straight and parallel ruts, as if large wagons had passed over them. These conform in their general direction to the shore, and are produced by the projecting edges of irregular masses of packed ice, borne along by the tidal current.

Essentially good and well-established reasons otherwise exist for believing that in the Gaspé peninsula at least, the period of the Middle Devonian was followed by a general coating of land ice. I have written somewhat at length upon this theme and it is not necessary to enter here into detail, but the premises are, first, the absence in the Gaspé succession, of any true late Middle or early Upper Devonian deposits; second, positive evidence of the ice-worn, ice-scratched morainic material outwashed and heaped together in beds beneath the Upper Devonian fish deposits of Migousha on the Bay of Chaleur. There is then reason for inferring that the late Devonian was a period of cold which brought the land ice down to what is now the edge of the sea at the northeast, and may well have created conditions, regardless of the alternation of the seasons,

which would give plenty of means for channeling the Devonian strands of New York, by the movement of land ice toward the sea or by the landward thrust of the sea ice back from the water.

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EXPLANATION OF PLATES

(All illustrations, unless otherwise stated, are from Portage slabs
and all are much reduced in size.)

Plates 7 and 8

7 is the original, 8 the plaster counterpart showing the true surface. For the purpose of reversing the relief, figure 8 is placed so that the depressions expand upward or toward the top of the plate. This is "mud flow"—7, as it is found in natural cast; 8, as it was made by rills flowing down the beach (from bottom to top of plate).

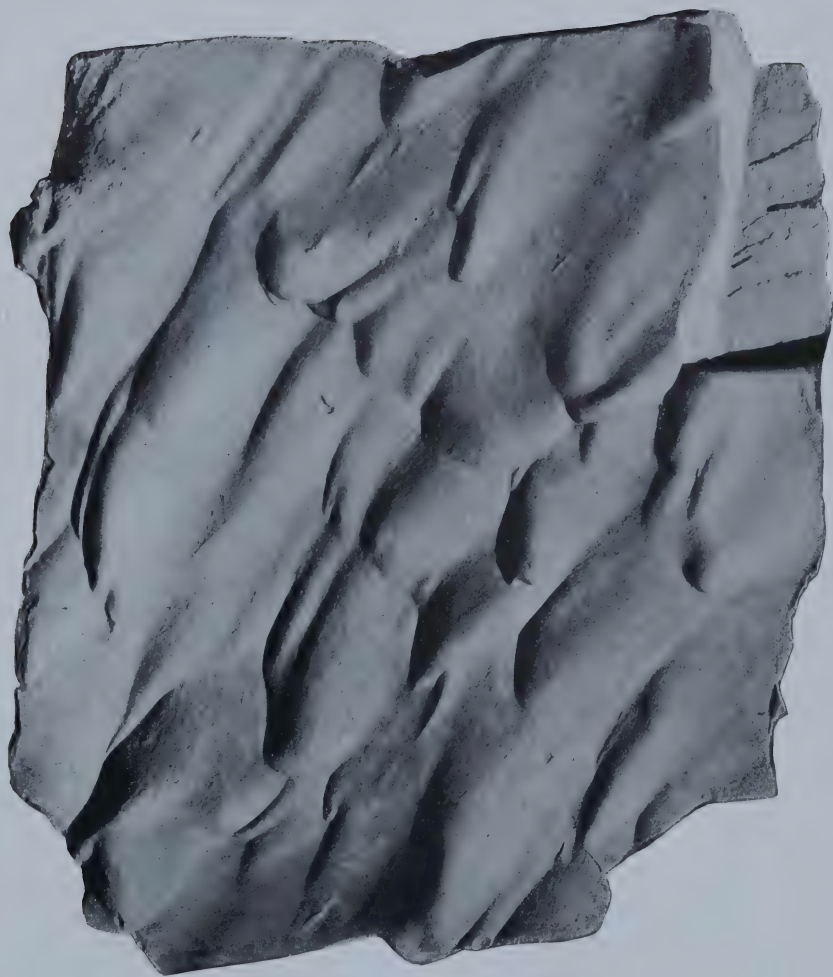
Plate 7



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Plate 8



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Plates 9 and 10

[213]

9 original; 10 counterpart; the latter placed so that the rill discharge is toward the bottom of the page. One may note here as on the preceding figures the flanges at the side of the rilled channels which indicate a stronger followed by a weaker flow of water; that is, the gradual running off of the wave or tide. At the sides of the slab are continuous channels and accessory markings; scratches and bruises of the sand are also evident.

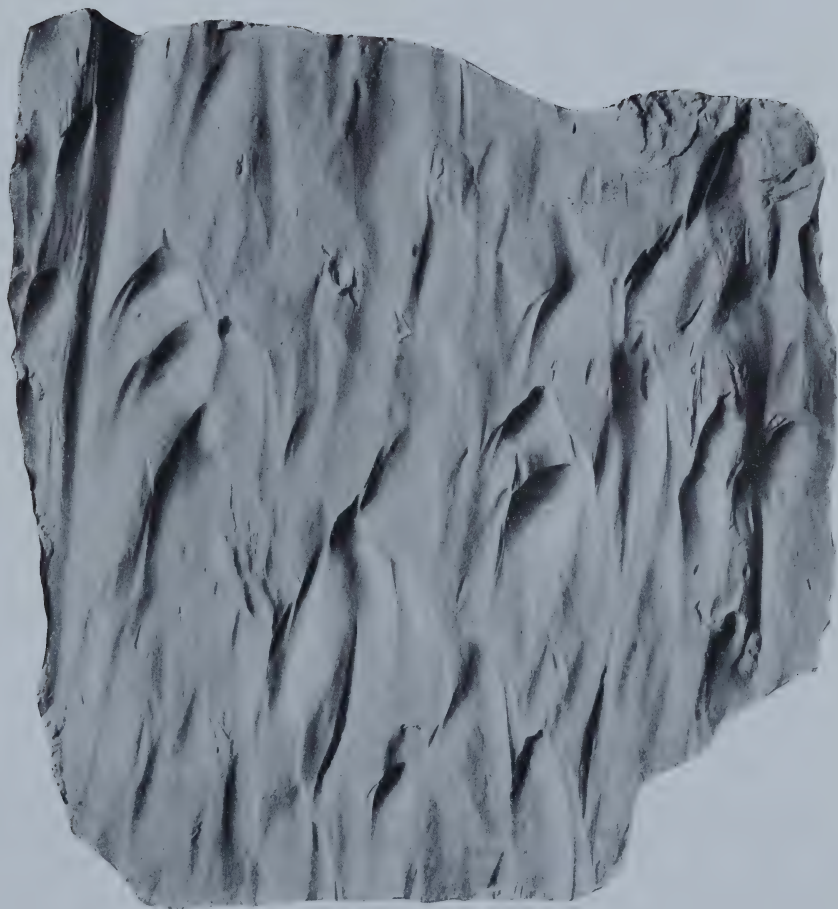
Plate 9



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Plate 10



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Plates 11 and 12

[215]

11 original; 12 counterpart. This "mud flow" is interesting as showing straight surface scratches made by objects carried down with such celerity and directness as to touch only the upper surfaces of the rilled channels. They are obviously later than rills. The flow is here downward to the right.

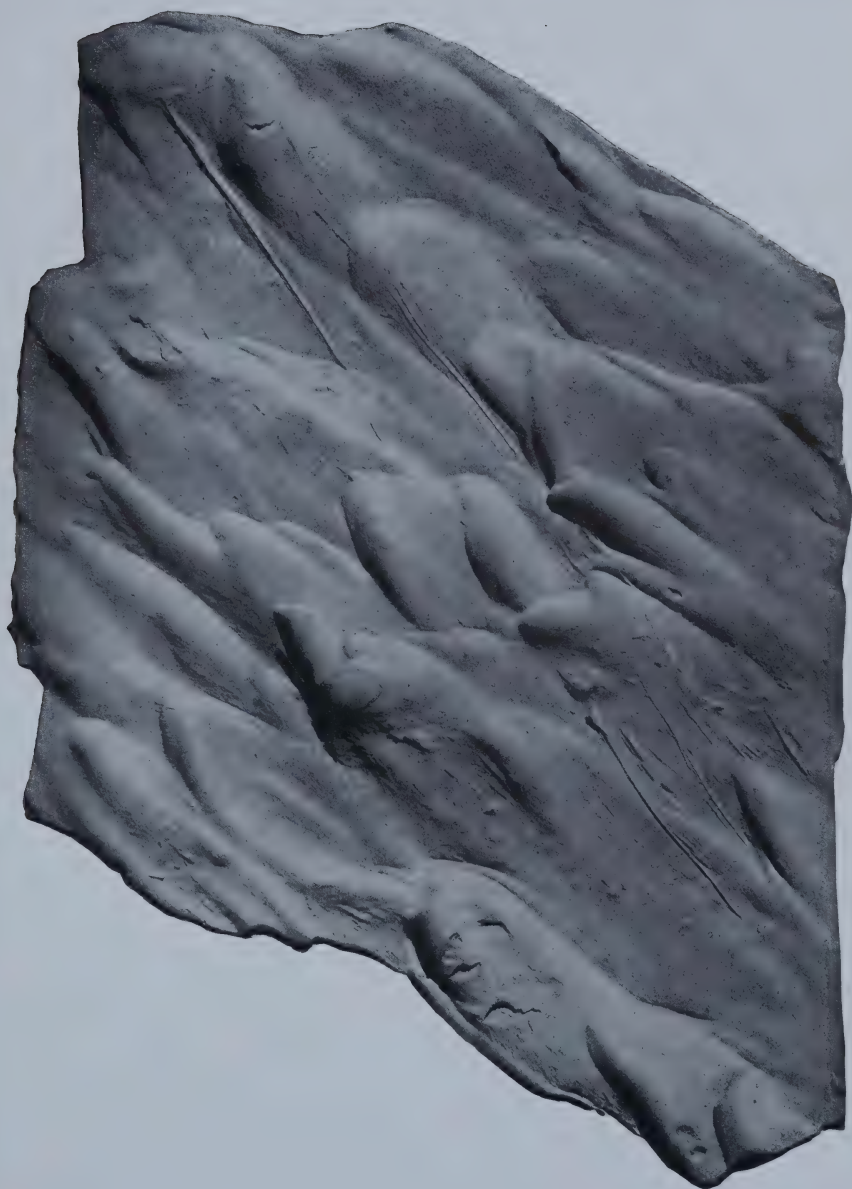
Plate 11



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Plate 12



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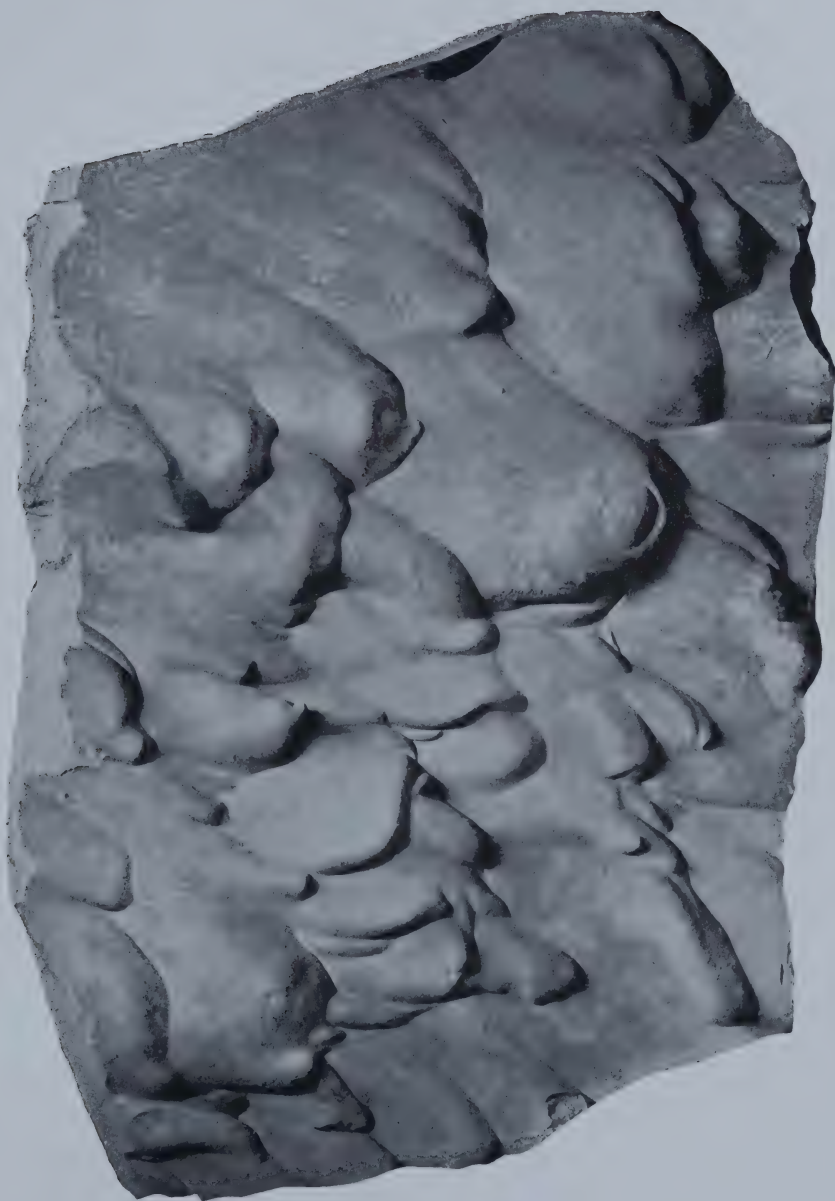
Plates 13 and 14

[217]

13 original; 14 counterpart. A very fine illustration of this sort of configuration.

[218]

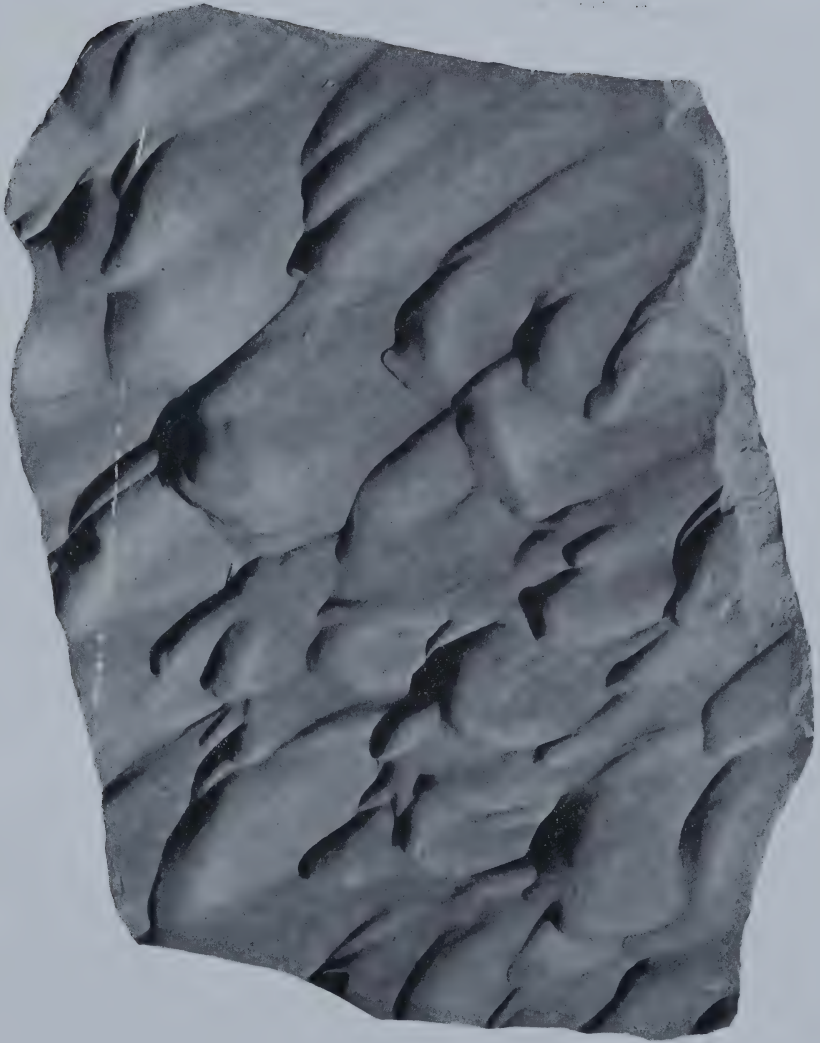
Plate 13



UNIVERSITY OF ALABAMA



Plate 14



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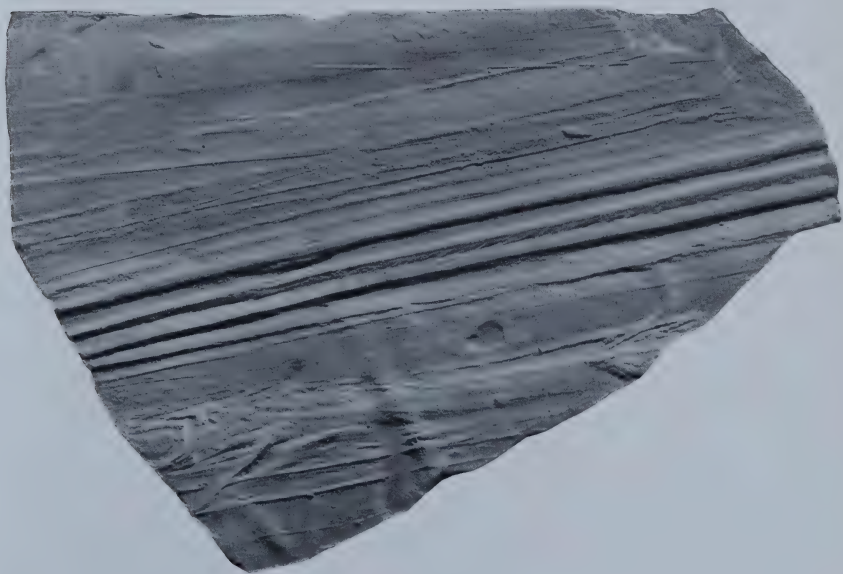
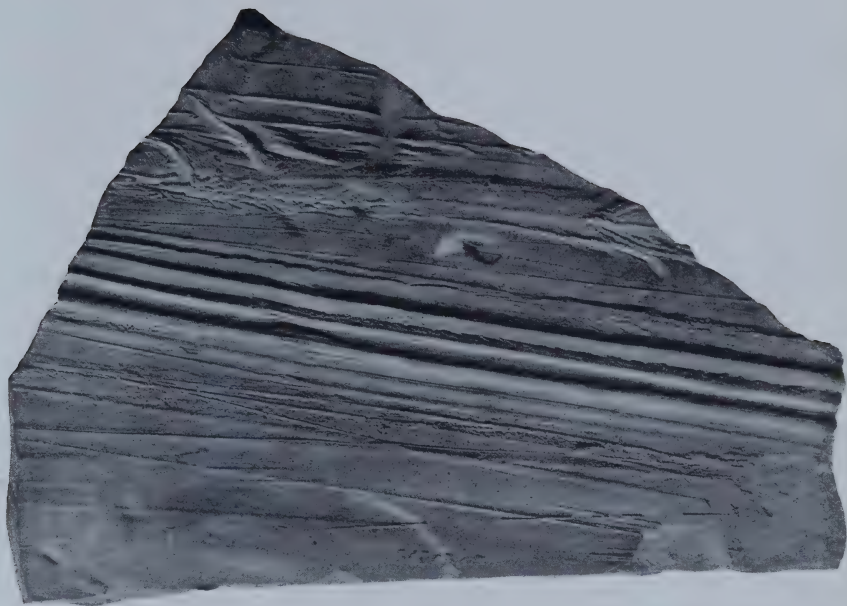


Plate 15

[219]

Original and counterpart. Grooved and striated surfaces. These two are so much alike because close reading with the eye does not readily catch the difference between them. General parallelism in the striae is accompanied by crossing lines and vibratory "chattering" is indicated. Striation as shown on the original is carried out with extreme delicacy.

Plate 15



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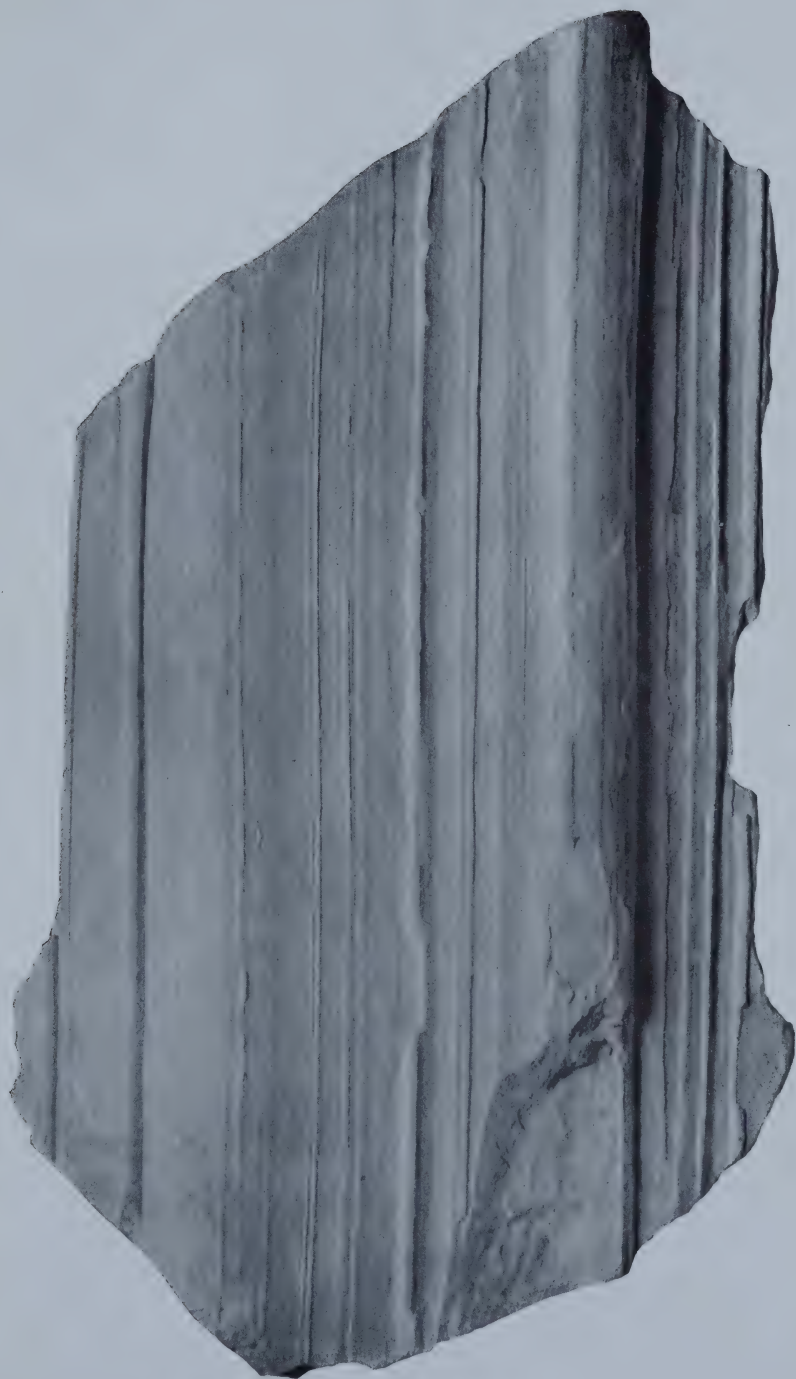
Plates 16 and 17

[221]

16 original; 17 counterpart. Deeply channeled (ridged) and finely striated slab.

[222]

Plate 16



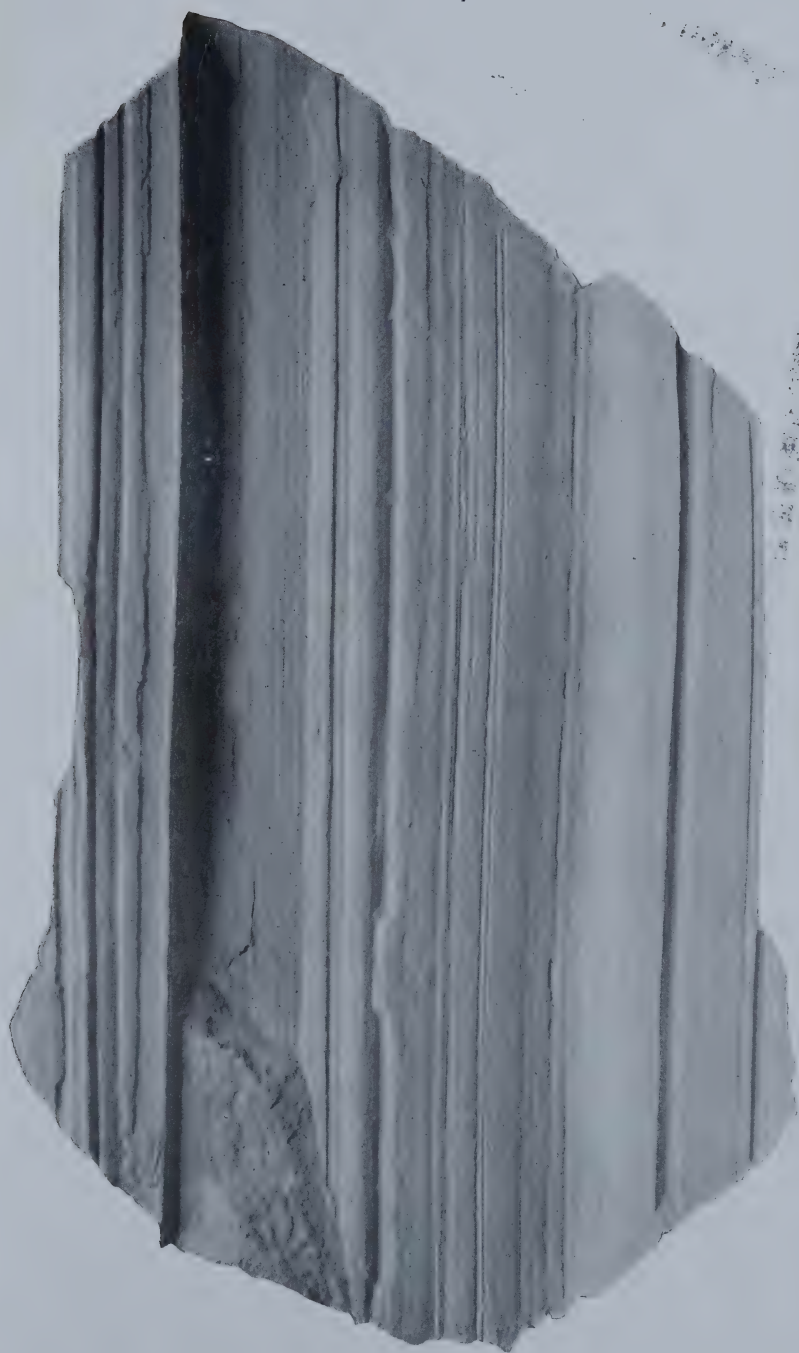
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Plate 17



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Plates 18 and 19

[223]

18 original; 19 counterpart. A single sharply angular and striated groove. The attempt to show the depth of the groove on the sand has not been very successful.

[224]

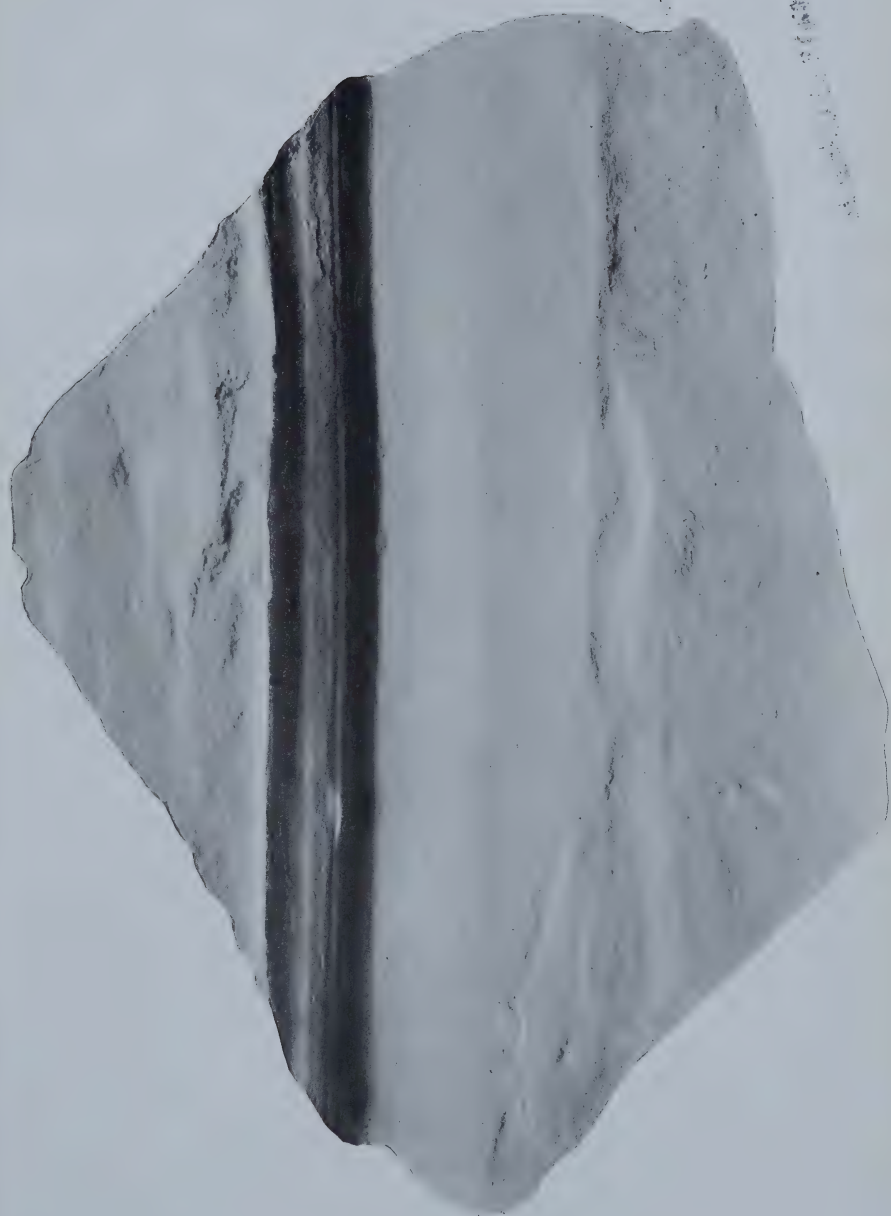
Plate 18



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Plate 19



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Plates 20 and 21

[225]

20. original; 21 counterpart. A typical slab of "*Fucoides graphica*"; short straight rods (depressions) with tapering and squared ends lying at various angles with reference to each other and to the bottom. Some of these angles are approximate to or suggestive of ice angles and there is observable a tendency to radiation from several centers.

Plate 20

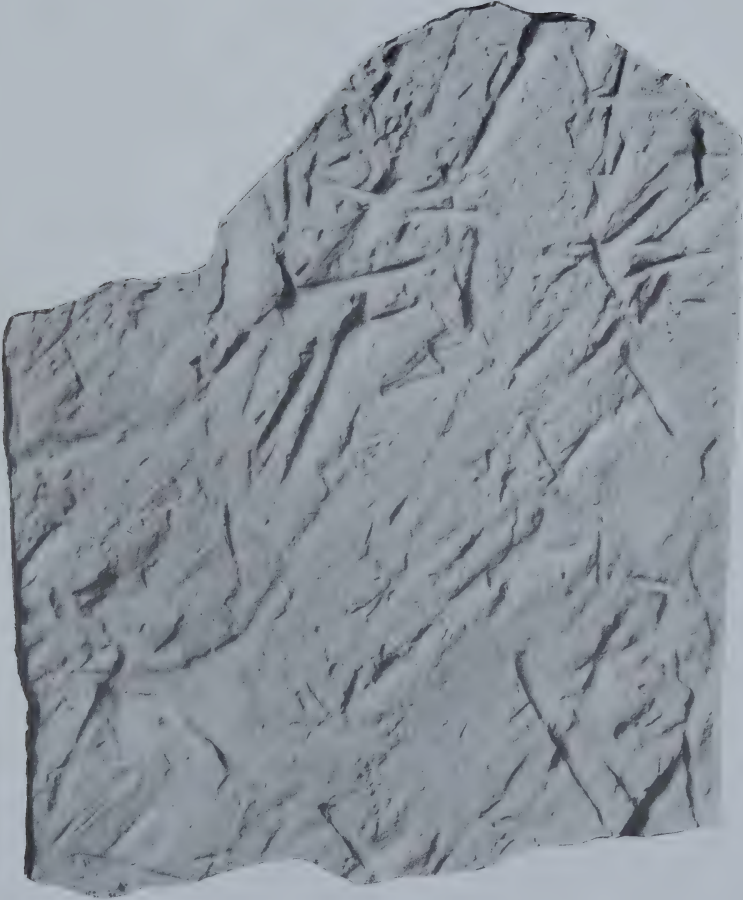


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Plate 21



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Plates 22 and 23

[227]

22 original; 23 counterpart. This slab shows the ice crystals, "Fucoides," lying on a surface of the sand in which is buried a goniatite shell (*Manticoceras*) and over which have been dragged two objects, presumably rough-edged stones set in ice, which have made deep and clearly striated channels. The interspaces show a fine parallel striation. It is seen that the ice crystals of the "Fucoides" formed on the sand after the grooves were made.

Plate 22



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Plate 23



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Plates 24 and 25

[229]

24 original; 25 counterpart. This is an illustration of the winnows or wave ridges of sand pushed together on the beach by successive overriding and retreating waves or wavelets. 24, the original, presents them as shallow, narrow, oblique grooves; 25, the true aspect of the surface, is placed so as to bring out the delicate relief as effectively as possible.

Plate 24

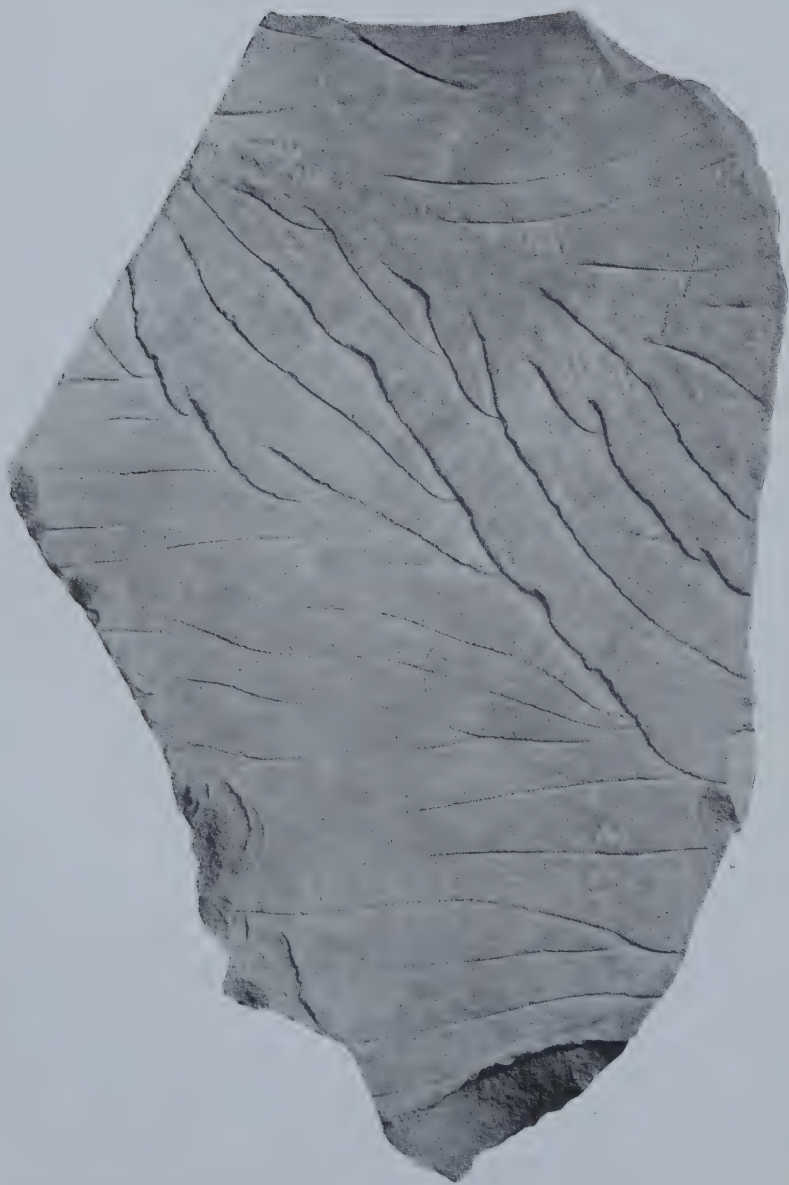




Plate 25



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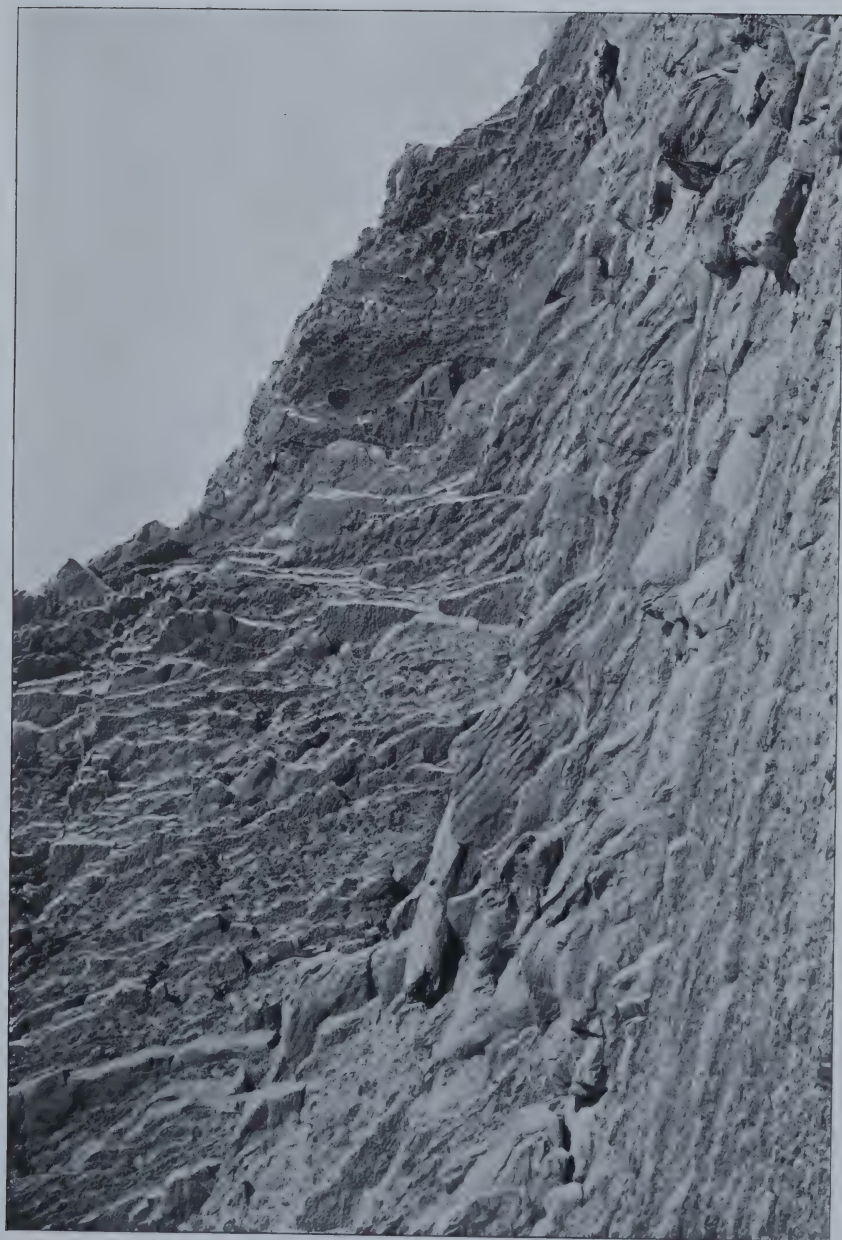


Plate 26

[231]

Vertical Silurian limestones in the cliff of Mt Joli, Percé, showing ripple and other strand markings on the under surface of the thin limestone plates.

Plate 26



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Plate 27

[233]

A closer view of the same, showing on various surfaces the casts of snail tracks or worm meanderings over the wet sand of the beach.

Plate 27



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Plate 28

[235]

Another part of the same section of jointed thin limestones with snail-tracked and polygonal ripple-marked layers.

Plate 28



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Plate 29

[237]

This view of the same cliff shows, on a limestone surface, the relief impressions of rill marks; the characteristic "mud flows" of the sandy strata elsewhere described.

Plate 29



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PRIMARY AND SECONDARY STRESSES

RECORDED BY THE VEIN SYSTEMS IN THE PERCÉ ROCK

BY JOHN M. CLARKE

(Plates 30-32)

The Percé rock in Gaspé, P. Que., to which reference has frequently been made in these publications, is a block of lower Devonian limestones standing almost on end. An isolated mass out of the flank of a great anticline of Appalachian type, it is a part of the mountain folds of the Gaspé peninsula. The strains to which it has been subjected through upturning of its strata were naturally manifold and as some part of these were torsional the rock mass has been considerably cross-checked by fissures now filled out of calcite veins.

There is, however, a very evident record of successive strains which, when closely read, gives an interesting clue to the history of the deformations; and this record is illustrated in plan by the accompanying sketch made by the writer. Doubtless there are like evidences of other disruptions which may point to later stages in the development of the rock mass.

In studying the figure on plate 30 the observer is looking down on the vertical strike edges of the strata, which are made up of limestones largely composed of fine sand grains stained brilliantly by red and yellow iron oxides, the former, a bright brick red, predominating. Of the two vein series crossing these strata, the older is an anastomosing network in which the main strands have a generally parallel direction. These veins are all solid white calcite, filling the fissures entirely and streaked lengthwise by black deposits of impurities. The veins of this series are of prevaillingly larger size than the others and may be several feet across. Generally they contain no inclusions of wall rock or other material and are thoroughly healed wounds of the rock mass.

The secondary series crosses the primary at a bold angle; in one place, however, a branch of this fissure series has opened along the middle of one of the primary veins. These veins are red in general cast of color, brighter even than the mother rock; carry well-defined wallbands of crystalline calcite and later bands upon these; they are filled with a breccia of small horses which are

partly fragments of the mother rock and partly pieces of the crystalline wall lining or a continuous laminated deposit of the calcareous red sand which composes the rock itself. Where broad, the veins are still open and lined with calcite crystals.

It is very obvious that these secondary fissures have been built in a different way than the primary. Torn-off parts of old fissure linings and bits of the rock itself may have got into them with the process of rending the strata, but the laminated sand deposits which completely fill the veins over a considerable extent can have come only from the washing into the open fissure of the sand resulting from the meteoric decomposition of the rock itself. It is to be conceived that these secondary fissures opening across the strata when exposed to weathering agencies, received from the wash of the rain, etc., the red limestone sand which now fills them.

The inference, therefore, is that however ancient the primary series of fissures may be, the secondary series is of relatively late origin.

The torsion stresses in these rocks are indicated by the photograph on plate 31.

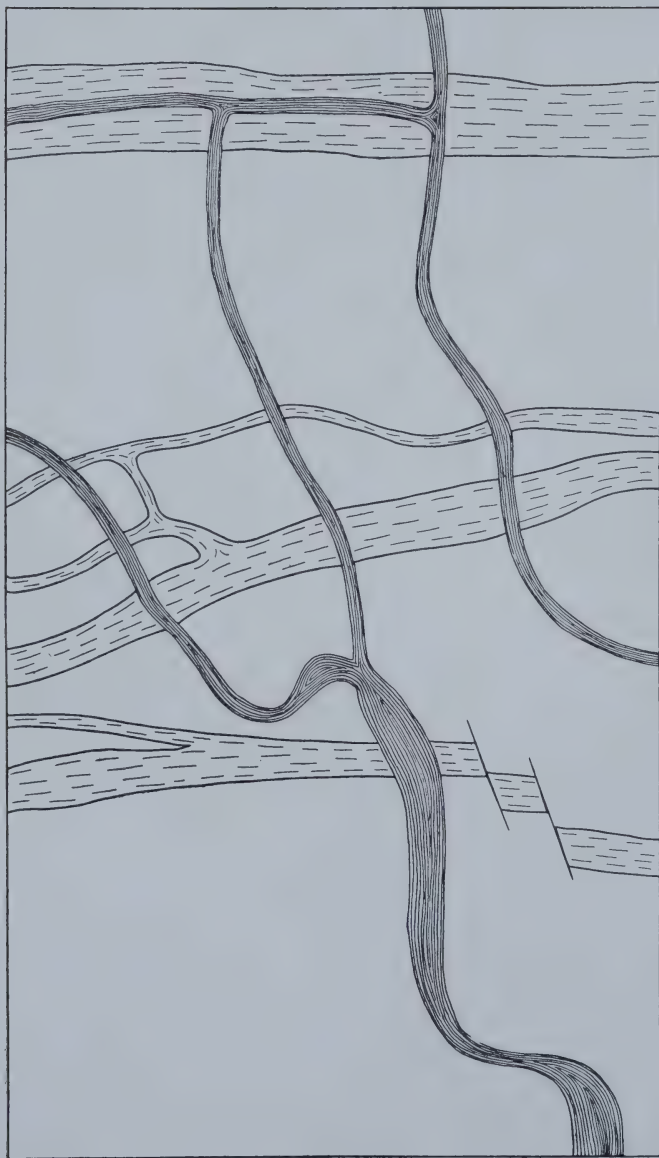
Plate 30

[241]

Sketch of primary and secondary series of veins in the Percé rock. The observer is looking down upon the strike edges of thin Devonian limestones.

[242]

Plate 30



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PLATE 31

Plate 31

[243]

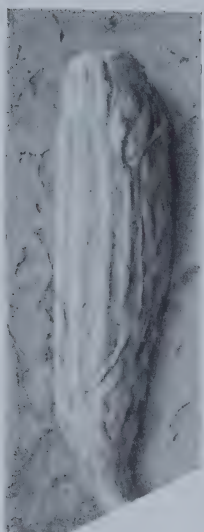
Figure 1. Sketch of a section of part of the secondary vein illustrated on plate 30. This shows the filling of the vein by solid calcite-carrying fragments which are parts of the crystalline wall of an earlier vein of the same series, and also a fragment of the red lime-sand filling of which this secondary vein is now largely composed.

Figure 2. A similar section of the secondary series of veins in which the entire vein-space is filled, with the exception of the crystalline wall lining, with red lime-sand derived by influx into the fissure from above.

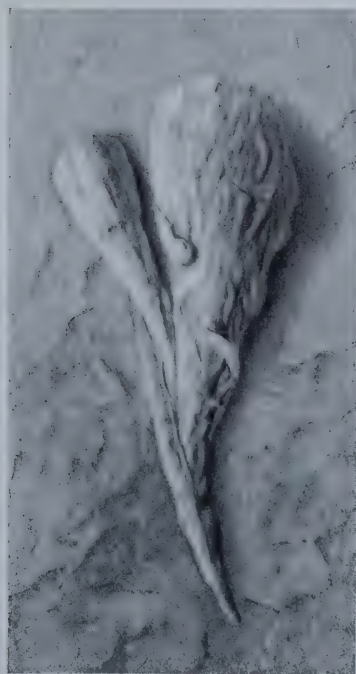
Figure 3. A fragment of the limestone showing a major vein at the bottom and the series of torsion veinlets departing therefrom.

Plate 5

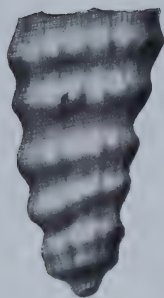
1



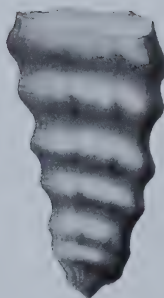
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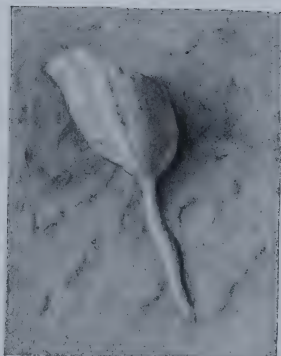
4



5



3



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Plate 32

[245]

Front view of the Silurian limestone pit at Mt Joli, showing a horizontal displacement of the beds, definitely bounded by undisturbed upper and lower surfaces. At X the vertical layer is not displaced but the fault that starts there and travels across the section shows actual displacement. This displacement is terminated by the layer which is shown at the left of the plate; unfortunately not fully shown in this photograph.

Plate 6



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THE MINING AND QUARRY INDUSTRY OF NEW YORK STATE

REPORT OF OPERATIONS AND PRODUCTION DURING 1916

BY D. H. NEWLAND

INTRODUCTION

The mineral industries of the State made a good record in 1916, and more than restored the losses that were experienced during the slump of the preceding year or two. Prices were more favorable than they had been for a long time, and the demand in many branches, particularly those related to metallurgical and chemical manufacturing, readily absorbed all the supplies that had accumulated as well as the year's production. It was a period of great activity and high prices.

An exception to the general prosperity obtained in the branches dependent upon the building trades, such as stone and clay wares, in which the conditions were not altogether favorable. Although prices were better than for some time, the scarcity of labor and the higher scale of wages served to restrain production and diminish profits. The cement manufacturers, however, had a good season.

A new item in the list of mineral products of the State, which helped to expand the total for the year, was zinc ore from the mines near Edwards, St Lawrence county. The initial market shipments were made in 1915, but the past year was the first in which operations were continuous throughout a twelvemonth. Owing to the fact that so far only a single company has been engaged in production of the ore for the furnace, the output is not listed separately in the table. Preparations were under way during the year to revive operations in some of the old zinc-lead mines in southeastern New York.

The statistics of production incorporated in the present report have been collected by the United States Geological Survey and the New York State Survey in cooperation; this plan was adopted by the two offices so as to diminish the task of collecting and compiling the information and to give uniformity to the results.

The summary of the various industries active in the State, as presented in the accompanying table, shows that the value of the year's production reached the sum of \$45,947,947, which established a new record. The best previous year was 1913 when the corresponding figures were \$41,598,399. As compared with the total for 1915, there was an increase in the value of \$9,667,508, or

about 27 per cent. It is to be noted in connection with the statistics that they are based for the most part upon materials in crude and first marketable forms, as they are shipped from the mine or quarry, rather than finished products, and consequently represent only a fraction of the total which are contributed annually by the mineral industries in the more general sense. If such materials as iron and steel, coke, sulphuric acid, carborundum, aluminum, alkali products, artificial graphite, etc., manufactured in the State were included, the total would amount to several times the aggregate returned by the particular industries covered in this report.

Mineral production of New York in 1916

PRODUCT	UNIT OF MEASUREMENT	QUANTITY	VALUE
Portland cement.....	Barrels.....	5 603 477	\$5 752 809
Natural cement.....	Barrels.....	104 415	51 635
Building brick.....	Thousands.....	982 942	6 497 270
Pottery.....	.....	.....	3 344 672
Other clay products.....	.....	.....	1 913 070
Crude clay.....	Short tons.....	11 158	36 413
Emery.....	Short tons.....	15 282	123 901
Feldspar and quartz.....	Short tons.....	20 379	115 311
Garnet.....	Short tons.....	5 840	198 200
Graphite.....	Pounds.....	<i>a</i>	<i>a</i>
Gypsum.....	Short tons.....	579 827	1 459 587
Iron ore.....	Long tons.....	1 464 917	5 571 429
Millstones.....	.....	.....	10 287
Metallic paint <i>b</i>	Short tons.....	14 572	34 296
Mineral waters.....	Gallons.....	7 746 490	697 650
Natural gas.....	1000 cubic feet..	8 594 187	2 524 115
Petroleum.....	Barrels.....	874 087	2 190 195
Pyrite.....	Long tons.....	<i>a</i>	<i>a</i>
Salt.....	Barrels.....	14 087 750	3 698 798
Molding sand.....	Short tons.....	661 673	570 898
Other sand and gravel.....	Short tons.....	7 436 424	2 073 931
Sand-lime brick.....	Thousands.....	15 851	109 337
Slate.....	Squares.....	2 727	21 345
Granite.....	.....	.....	368 119
Limestone.....	.....	.....	3 672 454
Marble.....	.....	.....	268 391
Sandstone.....	.....	.....	714 558
Trap.....	.....	.....	956 100
Talc.....	Short tons.....	93 236	961 510
Zinc ore.....	Short tons.....	<i>a</i>	<i>a</i>
Other materials <i>c</i>.....	.....	.....	2 011 666
Total value.....	.....	.....	\$45 947 947

a The output is reported under "Other materials" in last item of table.

b Iron ore sold for paint manufacture.

c Includes zinc ore, apatite, diatomaceous earth, graphite, marl, mica and pyrite. The value of the zinc ore is based on that of the metallic zinc recovered from the mine product.

CEMENT

BY ROBERT W. JONES

With the great increase in building construction which opened with the year 1916 there came a steady demand for the output of the portland cement plants in the State. Nine plants were in operation during the year as compared with 7 in 1915. One plant was temporarily out of commission due to destruction of a portion of the plant by fire. One new company began to produce. This plant is operated by the Acme Cement Corporation, in the Catskill district, having taken over the property of the Seaboard Portland Cement Company. The old plant of the Cayuga Cement Company, Portland Point, Tompkins county, after being extensively reconstructed is again in operation under the management of the Cayuga Cement Corporation. Properties at Phelps, Ontario county, were under examination for the production of portland cement.

There was during 1916 a total of 5195 feet of rotary cement kilns in operation as compared with 4019 feet in 1915 and 4499 feet in 1914. Of the total number of feet in operation during 1916, only 1750 feet were operating under the wet system. The total number of feet represents the combined length of 37 kilns varying in diameter from 5 feet to 12 feet and with a combined daily available output under normal conditions of 26,000 barrels.

After allowing 7½ cents a bag and four bags to a barrel, the price of portland cement f. o. b. New York, opened in January at \$1.37 and continued at this figure until May when it rose to \$1.42, where it remained until December, the year closing at \$1.62. This was a considerable increase over the selling price of the preceding year, when a maximum and minimum were \$1.32 and 92 cents respectively.

The factory shipments of portland cement in the State amounted to 5,603,477 barrels with a value of \$5,752,809 as compared with a production of 5,219,460 barrels and a value of \$4,175,528 for 1915. There were on hand at the mills on January 1, 1916, a total of 729,436 barrels, and at the end of the season on December 31, 1916 a total of 776,856 barrels. A little trouble occurred during the summer months in securing barge capacity for the Hudson River plants.

The Alpha Portland Cement Company has entered upon the production of potash for agricultural purposes, making a product in the form of a calcium salt carrying a minimum of 2¼ per cent soluble potash. This country before the war imported annually potash-bearing materials which if reduced to pure potassium oxide

would amount to practically 360,000 tons, with a value of \$20,000,000. The flue dusts and gases produced during the manufacture of portland cement generally carry a considerable percentage of the alkalis. It has been estimated that if all the cement plants carrying available potash in the United States could be equipped to produce this material, there would be an annual production equivalent to approximately 80,000 tons of potassium oxide.

Materials grouped under the heading of natural cement were produced to the extent of 104,415 barrels, with a value of \$51,635. The decline in production of natural cement was very great during 1916. In the previous year there was a production of 223,564 barrels with a value of \$134,138. There were 4 plants in operation with a combined total of 18 kilns. Of this number, 12 were of the continuous type of vertical kiln, having a daily available capacity, under normal conditions, of 90 barrels each; the others belong to the old style of intermittent vertical kiln of variable capacity.

The following table gives the statistics of cement production in the State for the period 1897-1916. The figures prior to 1904 have been taken from the annual reports of the *Mineral Resources*. It will be noted that the amounts given for the year 1916 represent shipment rather than production, but the difference is not important.

Production of cement in New York

YEAR	PORTLAND CEMENT		NATURAL CEMENT	
	Barrels	Value	Barrels	Value
1897.....	394 398	\$690 179	4 259 186	\$2 123 771
1898.....	554 358	970 126	4 157 917	2 065 658
1899.....	472 386	708 579	4 689 167	2 813 500
1900.....	465 832	582 290	3 409 085	2 045 451
1901.....	617 228	617 228	2 234 131	1 117 066
1902.....	1 156 807	1 521 553	3 577 340	2 135 036
1903.....	1 602 946	2 031 310	2 417 137	1 510 529
1904.....	1 377 302	1 245 778	1 881 630	1 207 883
1905.....	2 117 822	2 046 864	2 257 698	1 590 689
1906.....	2 423 374	2 766 488	1 691 565	1 184 211
1907.....	2 108 450	2 214 090	1 137 279	757 730
1908.....	1 988 874	1 813 622	623 588	441 136
1909.....	2 061 019	1 761 297	549 364	361 605
1910.....	3 364 255	2 939 818	292 760	147 202
1911.....	3 416 400	2 930 434	274 973	134 900
1912.....	4 495 842	3 488 931	287 693	142 165
1913.....	5 146 782	4 873 807	193 975	95 565
1914.....	5 667 728	5 088 677	232 076	115 117
1915.....	5 219 460	4 175 528	223 564	134 138
1916.....	5 603 477	5 752 809	104 415	51 635

CLAY

BY ROBERT W. JONES

The building trade industry for 1916 was affected by a variety of conditions. In general, construction was carried on at a higher rate than in the preceding year, although held back to a considerable extent by labor and transportation difficulties, both in regard to construction and production. A certain portion of this increase in construction is the result of a sudden demand due to war conditions and may not be considered as being permanent. There is, however, a heavier demand growing up for burned clay materials in construction, especially where fireproof conditions are concerned.

The following table gives the value of the output of clay materials in the State, exclusive of crude clay, for the last three years:

Production of clay materials

MATERIAL	1914	1915	1916
Common brick.....	\$4 597 856	\$4 886 734	\$6 433 266
Front brick.....	105 439	153 572	64 004
Paving brick.....	680 226	382 502	204 209
Hollow brick.....	38 119	59 683	<i>b</i>
Fireproofing.....	245 034	177 844	174 786
Terra cotta.....	892 630	647 815	714 041
Fire brick and stove lining.....	331 671	502 478	498 410
Drain tile.....	92 938	91 221	63 756
Sewer pipe.....	81 000	<i>a</i>	<i>a</i>
Pottery.....	2 405 676	3 064 274	3 344 672
Miscellaneous.....	4 630	36 250	257 868
Total.....	\$9 475 219	\$10 002 373	\$11 755 012

a Included under miscellaneous.

b Included under fireproofing.

During 1916 there were 216 plants in the State which were in a condition to produce clay products of various grades. Thirty-four of these plants were idle and 19 reported a production of pottery, for which the crude materials, except that used for red ware, were imported. Five plants producing miscellaneous burned products also secured their crude materials from sources outside the State.

Sales of burned clay material during the season had a value of \$11,755,012. Onondaga county led with a production of \$1,630,587, most of which is represented by sales of pottery. Ulster county occupied second place with sales amounting to \$1,444,275 made entirely of common soft mud building brick. Erie county

was third with sales of \$994,994, followed by Rockland county with \$809,019. Thirty-four counties of the State were productive, of which 32 reported a production of common soft mud brick, 8 reported a production of drain tile, 3 of paving brick and 7 of fireproofing.

The sales of common building brick for 1916 amounted to 977,085,000, with a value of \$6,433,266. The actual production during the same period was 945,348,000, with a value of \$6,196,284, as compared with 934,726,000 and a value of \$4,886,734 for 1915. Of this number during 1916, 59,414,000, were made by the stiff mud wire-cut process, with a value of \$445,112 as compared with 41,896,000 and a value of \$290,003 for 1915.

Production of clay materials by counties

COUNTIES	1914	1915	1916
Albany.....	\$369 312	\$447 344	\$459 665
Broome.....	<i>a</i>	<i>a</i>	<i>a</i>
Cattaraugus.....	334 557	180 290	157 676
Cayuga.....	8 765	9 800	8 100
Chautauqua.....	168 134	128 798	106 937
Chemung.....	<i>a</i>	<i>a</i>	<i>a</i>
Clinton.....	<i>a</i>		
Columbia.....	198 866	271 672	350 771
Dutchess.....	430 269	491 156	552 271
Erie.....	819 427	710 101	994 994
Greene.....	196 889	130 093	188 032
Kings.....	449 839	489 264	719 963
Livingston.....	73 775	724 267	170 982
Monroe.....	168 463	98 863	169 856
Montgomery.....	<i>a</i>	<i>a</i>	<i>a</i>
Nassau.....	96 534	92 559	135 931
Niagara.....	38 213	44 188	67 999
Oneida.....	45 000	159 400	80 100
Onondaga.....	I 556 093	I 293 022	I 630 587
Ontario.....	68 762	232 149	369 068
Orange.....	319 500	461 233	577 829
Queens.....	472 616	333 904	356 399
Rensselaer.....	124 152	233 332	116 994
Richmond.....	454 646	515 600	527 903
Rockland.....	747 026	446 583	809 019
St Lawrence.....	<i>a</i>	<i>a</i>	<i>a</i>
Saratoga.....	255 562	270 950	552 294
Schenectady.....	354 872	411 018	572 792
Steuben.....	<i>a</i>	<i>a</i>	<i>a</i>
Suffolk.....	69 300	66 600	96 097
Tompkins.....	<i>a</i>	<i>a</i>	<i>a</i>
Ulster.....	895 126	I 059 377	I 444 275
Warren.....	<i>a</i>	<i>a</i>	<i>a</i>
Washington.....	10 186	59 300	7 800
Westchester.....	321 826	303 558	170 547
Other counties.....	427 509	337 952	360 131
Total.....	\$9 475 219	\$10 002 373	\$11 755 012

a Included under other counties.

COMMON BUILDING BRICK

The year 1916 opened with great activity along the lines of building construction. Owing to this increase the supply of burned clay building material in stock had been drawn on to such an extent that very early shipments were necessary from the Hudson River yards. The productive season, of the Hudson valley, closed with approximately 60,000,000 bricks in the yards. During January common brick were selling in the New York market as high as \$10 a thousand with an average of \$9. This was the highest selling price for common brick since May 1906. During January 1915, there was sold in this market 8,400,000 Hudson river common as compared with 20,650,000 for the same period of 1916. Many of the larger yards produced throughout the winter months, bringing the stock in the yards to 135,000,000 at the opening of navigation. At the beginning of March common brick were selling at \$8.50 a thousand with a slightly smaller demand. In April the price dropped to \$8.25 and in May to \$8, with a final reduction at the end of the month to \$7.50. In June the price rose to \$8.25, resulting from a shortage due to labor difficulties. In July the price fell to a minimum of \$7 with an average of \$7.50. Clean brick from demolished buildings began to be a factor in the trade with a selling price of \$3 a thousand. In September building construction received a setback and combined with labor troubles on construction managed to hold the price at \$7.25. In October orders for future delivery began to be called and the price rose to \$7.75 with a further increase to \$8.25 for the first two weeks of November, the month closing at \$9.25. Transportation and labor troubles again affected the market. In December 6,000,000 bricks were unexpectedly placed on the market, but due to the heavy demand had no effect on the price which closed for the year at \$10 with a minimum of \$9.50.

Production of common building brick by counties

COUNTY	1915		1916	
	NUMBER	VALUE	NUMBER	VALUE
Albany.....	68 112 000	\$392 344	71 183 000	\$442 640
Cayuga.....	1 100 000	6 100	<i>a</i>	<i>a</i>
Chautauqua.....	3 905 000	31 187	<i>a</i>	<i>a</i>
Columbia.....	57 766 000	271 672	59 415 000	350 771
Dutchess.....	108 459 000	491 156	87 779 000	552 271
Erie.....	28 807 000	176 010	43 639 000	323 006
Greene.....	27 555 000	130 093	29 683 000	182 524
Monroe.....	7 738 000	38 690	<i>a</i>	<i>a</i>
Nassau.....	13 783 000	86 747	<i>a</i>	<i>a</i>
Oneida.....	22 200 000	154 200	10 320 000	78 100
Onondaga.....	22 635 000	155 376	22 486 000	166 260
Orange.....	84 997 000	461 233	80 450 000	577 829
Richmond.....	38 341 000	176 657	<i>a</i>	<i>a</i>
Rockland.....	87 917 000	446 583	121 967 000	809 019
Saratoga.....	53 390 000	267 950	92 010 000	549 894
Suffolk.....	11 100 000	66 600	<i>a</i>	<i>a</i>
Ulster.....	211 230 000	1 059 377	222 651 000	1 444 275
Westchester.....	47 619 000	278 955	18 357 000	126 197
Other counties.....	38 072 000	195 804	117 145 000	830 480
Total.....	934 726 000	\$4 886 734	977 085 000	\$6 433 266

a Included under other counties.

Hudson River region. The total production from this district was slightly less than the preceding year with an output of 691,485,000 and a value of \$4,485,526. The following table gives the production of the Hudson River region for the last two years:

Output of common brick in the Hudson River region in 1915

COUNTY	NUMBER OF OPERATORS	OUTPUT	VALUE	PRICE PER THOUSAND
Albany.....	11	68 112 000	\$392 344	\$5 68
Columbia.....	4	57 766 000	271 672	4 70
Dutchess.....	14	108 459 000	491 156	4 62
Greene.....	5	27 555 000	130 093	4 70
Orange.....	6	84 997 000	461 233	5 42
Rensselaer <i>a</i>	1	.....	.....	.....
Rockland.....	18	87 917 000	446 583	5 07
Ulster.....	21	211 230 000	1 059 377	5 01
Westchester.....	5	47 619 000	278 955	5 85
Total.....	85	693 655 000	\$3 531 413	\$5 09

a The output of Rensselaer county is included with that of Albany county.

Output of common brick in the Hudson River region for 1916

COUNTY	NUMBER OF OPERATORS	OUTPUT	VALUE	PRICE PER THOUSAND
Albany.....	11	71 183 000	\$442 640	\$6 21
Columbia.....	4	59 415 000	350 771	5 90
Dutchess.....	14	87 779 000	552 271	6 29
Greene.....	5	29 683 000	182 524	6 14
Orange.....	7	80 450 000	577 829	7 18
Rensselaer <i>a</i>				
Rockland.....	19	121 967 000	809 019	6 63
Ulster.....	22	222 651 000	1 444 275	6 43
Westchester.....	3	18 357 000	126 197	6 87
Total.....	85	691 485 000	\$4 485 526	\$6 48

a The output of Rensselaer county is not included with that of the Hudson river counties, having tidewater transportation.

CRUDE CLAY

Sales of crude clay as reported had a value of \$36,413. Of this amount, slip clays reported a total of over 50 per cent of all the crude clays shipped. The amount reported in excess of the slip clays was entirely for the production of red burned ware and coke oven use. This clay came almost entirely from Onondaga county.

FELDSPAR

The discussion as to the use of feldspar for the extraction of potash, noted in the previous issue of this report, was continued during the past year, but so far as known no definite steps were taken toward the establishment of an active industry. While it is generally agreed among chemical technologists that there is no special obstacle to the extraction of potash, so far as the methods are concerned, opinion seems to be divided in regard to the commercial outcome of the undertaking, in view of the probable reduction of market values with the close of the war. An establishment on a commercial basis would have to be of large capacity and would entail a correspondingly large initial outlay. The matter thus becomes mainly of financial nature.

Some difficulty would likely be encountered, however, in finding a suitable location for such an establishment. Most of the large feldspar deposits are situated in rather remote districts, where fuel and other needed supplies are not readily to be had. Another

matter which has not been adequately considered in the discussion hitherto is the amount of waste which would have to be dealt with in the working of most feldspar deposits. These are in the nature of coarse granites and carry quartz and other minerals besides the feldspar. Furthermore, very few occurrences contain the potash varieties alone (microcline and orthoclase) but usually they have considerable, if not important, amounts of the soda-lime varieties or the plagioclases. In nearly all the New York State occurrences the common variety of potash spar is microcline. Orthoclase is a rarity. The microcline often is intergrown with the soda variety (albite) in such manner that the two can not be mechanically separated, and thereby the potash content is brought down very considerably below the amount required by the chemical formula for microcline.

There were no important developments in the production of feldspar for pottery and other established uses, and the output, as reported, of 16,240 long tons valued at \$82,461 showed no material change from the total of the preceding year. The figures are inclusive of unsorted pegmatite, which is shipped by two quarries in the Adirondacks for roofing and other purposes. The active quarries included two in Essex county, one in Fulton and one in Westchester county.

A detailed account of the feldspar resources of the State was incorporated in the report of the New York State Museum, entitled "The Quarry Materials of New York," published in 1916. There is an abundance of the mineral among the crystalline formations of the Adirondacks and the Highlands, where it occurs in "giant granites" or pegmatite intrusions, some of which attain large size. Only a few of the large occurrences have so far been developed. The market for feldspar and the prices obtainable do not encourage extensive exploitation of the resources, and only under favorable conditions can deposits be profitably worked.

Among the factors that have to be taken into consideration in determine the possibilities of a particular occurrence, some relate to the intrinsic characters of the deposit which require more or less expert knowledge to determine. The geological features are important in relation to the form and probable extent of the body, since there is almost every variation in these respects to be met with among pegmatites. Tabular bodies or dikes, with parallel walls and of indefinite continuity downward, are rather the exception than the rule in the large workable occurrences. More commonly

these have a rounded, lenticular or irregular shape as seen on the surface, while the concealed portion is likely to be variable as well. Some pegmatites occur in normal granites as local differentiation phases and show gradation by imperceptible stages on the borders, but such rarely exhibit so coarse crystallization as the separate intrusions. The size of the crystal individuals is a factor of practical importance, since it affects more or less the work of sorting and cobbing. In all quarry operations, except those connected with the production of roofing material, there is considerable waste in the preparation of the shipping product, the proportion varying with each separate occurrence. In some the loss may amount to fully one-half of the rock broken down, represented by quartz, lime-soda feldspar, and the less important silicates like mica, hornblende, tourmaline etc., the presence of which is detrimental to the use of the spar for pottery manufacture.

The other factors that need to be considered are the situation with respect to shipping facilities and the distance to market. The selling prices, which in recent years have ranged between \$3 and \$5 a long ton for selected crude spar of pottery grade, impose narrow limits upon the costs of haulage and freights. The market centers are Trenton, N. J., and East Liverpool, Ohio, where are situated the largest pottery manufacturers. The local pottery industry, though important, does not afford a sufficient outlet for the quarry product of the State.

GARNET

The production of abrasive garnet last year was stimulated by the widespread industrial activity and by the curtailment of supplies of foreign abrasives owing to the high ocean freight rates. The Adirondack mines, which yield the larger part of the domestic supply, reported a gain of about 50 per cent in the year's shipments, a very encouraging increase after the general dulness which has obtained in the industry in recent years. The output has averaged around 4000 tons, and only a few times has it exceeded 5000 tons. The output for 1916, however, established a new record.

The largest operations in the Adirondack region were carried on by the North River Garnet Co., at Thirteenth Lake, near North River, Warren county. This company has a large, open quarry in a great body of garnetiferous gneiss that consists of acid feldspar and hornblende, with garnet crystals rather plentifully distri-

buted through the mass. The gneiss has the appearance of a metamorphosed igneous rock allied to the syenitic class which is so abundant in the eastern and northern Adirondacks. The garnet crystals range from a fraction of an inch up to 4 or 5 inches in diameter. It is only occasionally that they possess crystal boundaries and then show dodecahedral development with a parting parallel to the crystal faces. They are of dark red color, translucent on thin edges. The garnet is extracted by mechanical means, the rock being crushed and passed through jigs of special design which effect a good separation although there is only half of a unit difference in the gravity of the garnet and the hornblende. The product has a bright, fresh appearance of typical garnet color. It is shipped unsorted, the sizing being done by the manufacturers.

The Rogers quarry on Gore mountain in the same vicinity has been operated for many years by H. H. Barton & Son Co. and is the oldest of the Adirondack workings. It is based on a long, narrow band of hornblende schist or amphibolite, which may represent either an altered dike of gabbro or an inclusion of Grenville gneiss in the country syenite. The garnet occurs in roundish masses and aggregates which are probably crystal individuals, though not regularly bounded. It shows the effects of deformation and crushing, so much so that the masses shell or break down readily when they are exposed, yielding small fragments which are bounded by one or more smooth surfaces that represent the dodecahedral parting, characteristic of the crystal garnet. The individual crystals attain very large sizes, some of them yielding many hundred pounds of broken garnet. The extraction of the garnet is by cobbing and hand picking.

The Wevertown quarry of the Warren County Garnet Mills turns out a product that is rather different from the others, the garnet being less distinctly of crystalline habit and of lighter color. It is associated with pyroxene, the two minerals constituting the rock which is undoubtedly a metamorphosed limestone. In some parts of the workings the garnet occurs in nearly solid masses. A very similar occurrence was worked for a time near Keeseville. The product when crushed is of granular rather than platy character.

The total shipments from the Adirondacks last year amounted to 5840 short tons with a value of \$198,200. The figures are not strictly comparable with the statistics of previous years, which represented production and not sales. The output in 1915 was reported as 3900 short tons valued at \$134,064.

In recent years small amounts of garnet have been imported from Spain for manufacture, in competition with the domestic product. The quantity so imported in 1915 was 1343 short tons with a declared value of \$24,472. No figures of the amount imported in 1916 have been obtainable, as no record was made of the tonnage that passed through the customs office, although the value was given as \$43,481.

GRAPHITE

Trade conditions in the graphite industry last year were quite unprecedented. The demands for crucible grades far exceeded the supply and there was a marked advance in consequence in the prices of crystalline graphite, both domestic and foreign. Since the outbreak of the present war the consumption has increased greatly on account of the requirements for crucible steel and for brass manufacture, both of which industries have experienced a tremendous expansion in connection with the making of ammunitions. The shortage of supply has been in part an artificial condition, resulting from the scarcity and high costs of shipping and also from the embargo which the British and French governments put upon the importation of graphite from Ceylon and Madagascar in the first year of the war. This embargo was later removed, so that importations could be made under certain guaranties and restrictions; but still the imports, which last year exceeded all records, supplemented by a large domestic production, did not meet the needs.

The imports of crystalline graphite for the last five years have been as follows: In 1916, 64,120,000 pounds valued at \$6,933,731; in 1915, 45,064,000 pounds valued at \$2,049,792; in 1914, 22,166,000 pounds valued at \$1,107,192; in 1913, 38,756,000 pounds valued at \$1,835,530; and in 1912, 39,220,000 pounds valued at \$1,506,934. Of the quantities given, all but a small proportion each year has come from Ceylon, the remainder having been supplied by Madagascar, Korea, Canada and other countries. The domestic production, as given by the United States Geological Survey, for the same period has been as follows: 1916, 10,931,989 pounds worth \$914,748; 1915, 7,074,370 pounds, \$417,273; 1914, 5,220,539 pounds, \$285,368; 1913, 5,064,727 pounds, \$254,328; 1912, 3,543,771 pounds, \$187,689.

The highest market prices are commanded by the Ceylon graphite in lump form, for which as much as 25 to 30 cents a pound was paid in 1916. The domestic flake graphite of the best quality was sold at 12 to 15 cents a pound. A reduction on these prices should be made of course for the lower grades, which in regard to domestic

graphite include the smaller and more impure flake, but no regular scale of prices can be given. The commercial grades of the domestic crystalline graphite show wide variations in respect to purity, the best carrying 90 to 95 per cent carbon.

There is some doubt as to the ability of Ceylon to meet the increasing demands for its product. According to expert testimony the mines on the island are worked at about their full capacity under the present system of operations, which is quite primitive. This seems to be borne out by the record of exports, which have shown no decided tendency toward expansion during the last decade. On the other hand, Madagascar is likely to forge ahead and become a very important factor in the world's markets, judging from the progress it has made within the last year or two. The industry there was started less than 10 years ago, and the product for the current season promises to reach 40,000,000 pounds, according to a recent article in "The Engineering and Mining Journal,"¹ which is about two-thirds of the average quota of Ceylon.

The active general market conditions were reflected in the year's developments in the local mining industry which reported a good gain in the output, with an outlook for a still further enlargement of the production during the current season. This will undoubtedly follow, inasmuch as two new companies have already started productive operations and should make a considerable increment to the previous year's total. The list of producers for 1916 included the American mine of the Joseph Dixon Crucible Co. at Graphite, the Graphite Products Corporation of Saratoga Springs, and the Popes Mills Graphite Co. of Popes Mills, St Lawrence county. The recent mining developments in the Adirondack region are covered in the following notes.

American mine. This is the oldest of the Adirondack mines now active, having been continuously in operation for about 40 years, and probably is the most productive mine of its kind in the country. It is based on layers of graphitic quartzite, interbedded with Grenville limestones and garnet-sillmanite gneiss, that outcrop some 6 miles west of Hague on Lake George. There are two principal deposits, which outcrop with an interval of a few hundred feet between but follow the same northeasterly course and southeasterly dip. The two are probably the broken faulted members of one series, inasmuch as both are characterized by similar geological relations. Most of the mining hitherto has been done in the north-

¹ July 7, 1917.

western or main deposit, which extends from near the present mill where the incline shaft is situated southwest to the limits of the property, a distance of fully one-half of a mile. This has been worked almost entirely underground, the bed which ranges up to 30 to 35 feet thick being stoped in drifts which run off from the incline to the southwest. The dip is low, 20° to 25° ordinarily, but may change suddenly to 45° or 50° ; the bed varies greatly in thickness, as it has been squeezed into a succession of bulges and constrictions so that it is in places really a series of lenses separated by varying intervals in which the quartzite is reduced to a thin seam. Occasionally a subsidiary graphite deposit occurs in the foot or hanging of the main deposit. In the last year considerable attention has been given to the Summer bed, which for a long time has lain idle. It was opened in the early nineties, mostly by pits situated along the outcrop and following only short distances down the dip. The length of outcrop is around 700 feet. On the northeast end it begins on the surface as a thin band only a foot or so thick, but widens rapidly to the southwest to 6 to 8 feet and has recently been mined down to 150 feet on the dip. After another interval it pinches again to a foot or less, only to open out once more, showing that the deposit here also consists of a succession of lenses. The bed has been explored on the dip onto the adjoining Wheeler property, of which the mining rights are held separately. The relations of the two beds have importance in regard to the future mining operations, since the reserves of ore would be likely to be much greater in case there were two distinct beds. The circumstances in evidence, however, point to a repetition by faulting of a single ore zone.

Graphite Products Corporation. This company with mines and mill near Kings station, 4 miles north of Saratoga Springs, was engaged in active production during the year, after having carried out an extensive program of construction and development on the property. The company succeeded to the ownership of the holdings of the Saratoga Graphite Co., which had performed little more than experimental work on the property. The mines were enlarged and equipped for economical operation, and a new mill with 15 stamps and approved devices for separating the graphite was erected by the company. The year's record of operations was reported as very satisfactory. The graphite appears in two main series of outcrops, which may be displaced parts of a single zone as is the condition on the Dixon property, and the beds have been intruded by amphibolite and pegmatite so that their structures are

rather difficult to determine. In the main workings which lie near the summit of the ridge to the southwest of the mill the bed ranges up to 25 feet or more thick and is worked partly under cover and partly as an open cut.

The matrix of the graphite is a thin-bedded schist, carrying a good deal of feldspar and sporadically more or less mica, in addition to quartz. It is rather heavily charged with pyrite and the exposed edges of the beds have been decomposed into an iron-stained clayey material which is relatively enriched with graphite. The flake varies in size, a good proportion being fairly coarse. Plans have been considered for increasing the output, which will necessitate an addition to the milling plant but little change in the mine equipment.

Hooper Brothers' mine. This is a new property, situated in the vicinity of South bay, west of Whitehall, Washington county. The first development work was undertaken in the late summer of 1916 by the present owners, Messrs F. C. and George Hooper, and so rapidly was the development and construction work carried forward that the property was ready for commercial operations in the early part of 1917. The deposit combines many advantages for economic production, and it seems remarkable in view of its size and exposed situation—lying within the narrow peninsula between Lake George and Lake Champlain—that the deposit should not have been brought to attention long ago. The outcrop of the graphite bed is on the northern flank of the ridge called the "Diameter" which rises from the western shore of South bay, about 4 miles due west from Whitehall, which is the shipping point. The old Burgoyne road, built by the British general of that name, crosses the property.

On the south side of Diameter, next the bay, is the mine of the Champlain Graphite Co., now inoperative, no doubt located on the same bedded series but under much disturbed conditions, due to faulting and igneous intrusion. The deposit on the Hooper Brothers' property outcrops along a low ridge facing north with a continuous exposure for over 3000 feet; for much of the distance the exposed edge forms a steep wall, of which the base is formed by garnet gneiss conformable with the graphite schist, while the ridge is capped by a sheet of gabbro that apparently was intruded along the bedding planes of the schist overlying the graphite and later uncovered by erosion. The whole series dips to the south at an angle of 20° or so. The layer of graphite schist measures 40 feet or more in maximum thickness. Samples have returned up to 15 per cent graphite, but the average of course is less by several

per cent. The flake is medium to coarse, some of it unusually large and thick for this type of occurrence. There is little mica in evidence.

The mill stands near the eastern end of the ridge where a favorable slope of the ground provides ample storage for the tailings. The ore is broken in a preliminary crusher and reduced by stamps, after which the separation of the graphite is effected by tables and buddles according to the general plan employed in the Adirondack mills. The mill product is now shipped without refining, but it is the plan of the owners to provide facilities for turning out refined flake graphite and to market the product in that form.

GYPSUM

Market conditions in the gypsum industry which had been rather unfavorable to the producers during the preceding year or two showed distinct improvement in 1916. There was a better demand for calcined plasters, the principal products made from gypsum, and also a slightly increased demand for crude gypsum in portland cement manufacture. As a result the local mines extended their operations wherever this was possible and attained a new level of output, well above that of the most prosperous year of previous record.

The market for calcined plasters, in keeping with conditions in nearly all the building trades, was upset by the war, and furthermore suffered for a time from an excess of productive capacity which conduced to extreme rivalry for trade among the individual producers. It would appear that this feature has been removed from the situation, at least for the present. In fact last year the local concerns were unable to keep pace with the market demands, which were somewhat abnormal owing to the curtailment of imports that ordinarily enter the New York and New England markets in large quantities. Most of the imported gypsum comes into the country in crude form to be converted into plasters by calcining plants situated along the seaboard. Nova Scotia is the principal source of the material, and the falling off in supply has been owing to high freights and not to any impairment of the productive resources of that country.

The production of gypsum and its products in New York State for 1915 and 1916 is shown in the accompanying table. The figures given for wall plasters in the last item of the table cover only the amounts that were made from local rock by plants operated in connection with the mines. The actual output of such plasters is

much greater than is indicated by the table, since large quantities in addition are made by local plants from imported materials. Of the total product of crude gypsum last year, about two-thirds was converted into calcined plasters (plaster of paris, stucco and wall plasters) by the companies who operated the mines, and the remaining third was sold in crude form, principally to portland cement mills, or ground to land plaster.

Production of gypsum in New York

MATERIAL	1915		1916	
	SHORT TONS	VALUE	SHORT TONS	VALUE
Total output, crude.....	516 002	.....	579 827	.....
Sold crude.....	162 686	\$241 511	188 077	\$273 322
Ground for land plaster.....	6 536	13 486	7 169	18 710
Wall plaster, etc., made....	292 344	1 006 203	311 264	1 167 555
Total.....	.....	\$1 261 200	.....	\$1 459 587

The production in 1916 was reported from five counties (Onondaga, Cayuga, Monroe, Genesee and Erie) situated in central and western New York along the belt of Salina strata which hold the gypsum. The Salina beds are mostly shales, with limestones near the top, inclosing beds of rock salt and massive gypsum. The greatest thickness of the formation is in Onondaga and Cayuga counties where the beds altogether measure 1000 feet or more from the base to the top. Here also occur the heaviest layers of gypsum, ranging from 20 to 60 feet, the latter thickness being attained in the vicinity of Fayetteville and Jamesville, Onondaga county. The gypsum in the western section seldom exceeds 6 or 8 feet in thickness.

There is a great difference in the grade of the gypsum that is obtainable in the different deposits. The percentage of hydrated calcium sulphate, or gypsum substance, ranges from 65 to 70 per cent in the more impure sorts to 95 per cent in the best rock. The impurities consist of clayey matter and the carbonates of lime and magnesia. The variation is not altogether without rule, for it can be stated in general that the grade improves progressively from east to west, the best quality of rock being found in Genesee and Erie counties on the extreme west end of the belt, while on the east end in Madison, Onondaga and Cayuga counties the average

material does not carry much above 75 per cent in gypsum. It is for this reason that the bulk of the output now comes from the western section, despite the advantages that the eastern deposits have in regard to size and accessibility.

All the mines are situated on the outcrop of the deposits and are opened usually by adits or tunnels on the level of the beds, although in one or two mines access to the workings is through shallow shafts. There are no mines now operated under more than 100 feet of cover. With the exhaustion of the resources in the outcrop mines the workings will have to be extended in depth, to the south of the outcrop, where it would appear that deposits of similar character to those now worked are to be found.

Very little exploration has been carried on of late years in the gypsum belt. The period of greatest development was from 1900 to 1907, when the mines in the western section, that is Genesee and Erie counties, were opened and rapidly gained the lead which they have since maintained. In the last year the testing of deposits near Victor, Ontario county, has been under way, but it is not known just what results were obtained.

IRON ORE

The unprecedented conditions in the iron trade which obtained during the year 1916, when production and consumption proceeded at rates that are absolutely without parallel in the history of the industry, showed their influence upon the local mining developments and the statistics of output as returned by the active companies. The shipments of lump ore and concentrates by New York mines amounted altogether to 1,464,917 long tons, valued at \$5,571,429, a new record and representing a gain of over 50 per cent in the total for the year.

The details of the record will be found in the accompanying table, which gives also the figures for the past two decades. In comparing the statistics of the table it should be noted that those for 1916 represent shipments, while in previous years the mine output has been the basis of compilation. As a matter of fact, however, there is rarely any wide variation between the quantity of ore mined in any one year and the shipments for the same period, since little of the product is held in stock at the mines but is sold on yearly contracts.

The shipments consisted of magnetite, hematite and limonite in the order of their importance. A total of 1,402,859 long tons consisted of magnetite in the form of lump ore and concentrates from

the Adirondacks and the southeastern Highlands. The hematite amounted to 61,712 long tons, all of it from the Clinton district; while the remainder consisted of a few hundred tons of limonite from Columbia county. The magnetite was made up of 802,241 long tons of mill concentrates and 600,618 long tons of lump ore. The concentrates averaged over 60 per cent in iron, the bulk of the shipments carrying 63 to 65 per cent. The lump ore contained 58 to 60 per cent iron. In the concentration of magnetite as practised in the Adirondacks, each ton of finished product represents from a little over 1 to nearly 3 tons of crude ore, the ratio varying with each deposit. Improvements in the methods of mining and milling have made it possible to handle ore running as low as 25 per cent on a profitable basis.

The amount of ore hoisted exceeded the shipments by several hundred thousand tons, the difference being accounted for by the shrinkage due to the concentration of the magnetite ores. The actual mine output in 1917 was a little over 2,000,000 tons, considerable more than the total for any preceding year.

Production of iron ore in New York State

YEAR	MAGNETITE	HEMATITE	LIMONITE	CARBONATE	TOTAL	TOTAL VALUE	VALUE A TON
	Long tons	Long tons	Long tons	Long tons	Long tons		
1897	296 722	7 664	20 059	11 280	335 725	\$642 838	\$1 91
1898	155 551	6 400	14 000	4 000	179 951	350 999	1 95
1899	344 159	45 503	31 975	22 153	443 790	1 241 985	2 80
1900	345 714	44 467	44 891	6 413	441 485	1 103 817	2 50
1901	329 467	66 389	23 362	1 000	420 218	1 006 231	2 39
1902	451 570	91 075	12 676	Nil	555 321	1 362 987	2 45
1903	451 481	83 820	5 159	Nil	540 460	1 209 899	2 24
1904	559 575	54 128	5 000	Nil	619 103	1 328 894	2 15
1905	739 736	79 313	8 000	Nil	827 049	2 576 123	3 11
1906	717 365	187 002	1 000	Nil	905 367	3 393 609	3 75
1907	853 579	164 434	Nil	Nil	1 018 013	3 750 493	3 68
1908	663 648	33 825	Nil	Nil	697 473	2 098 247	3 01
1909	934 274	56 734	Nil	Nil	991 008	3 179 358	3 21
1910	1 075 026	79 206	4 835	Nil	1 159 067	3 906 478	3 37
1911	909 359	38 005	5 000	Nil	952 364	3 184 057	3 34
1912	954 320	103 382	Nil	Nil	1 057 702	3 349 095	3 17
1913	1 097 208	120 691	Nil	Nil	1 217 899	3 870 841	3 18
1914	703 670	47 705	341	Nil	751 716	2 356 517	3 13
1915	873 422	70 147	834	Nil	944 403	2 970 526	3 15
1916	1 402 859	61 712	346	Nil	1 464 917	5 571 429	3 80

The list of active mining companies for the year included the following in the Adirondack region: Witherbee, Sherman & Co. and Port Henry Iron Ore Co., Mineville; Chateaugay Ore & Iron Co., Lyon Mountain; Cheever Iron Ore Co., Port Henry; Benson Mines Co., Benson Mines. The last two companies were active only for part of the year, the Benson mines operating only for a short period in an experimental way to test the new process of mill treatment that had been installed on the property. In southeastern New York the Hudson Iron Co., Fort Montgomery, and the Sterling Iron & Railway Co., Lakeville, maintained operations on the usual scale. The hematite mines included those of C. H. Borst, Clinton; Furnaceville Iron Co., Ontario Center; and Ontario Iron Co., Ontario Center. The single limonite mine near Boston Corners, Columbia county, was worked by Barnum, Richardson & Co., of Salisbury, Conn.

Mineville. The most active year in the history of this district was indicated by the reports of the mining companies, whose combined output was nearly 1,500,000 tons of crude ore. The more productive properties were the Old Bed, Harmony and Barton Hill of Witherbee, Sherman & Co. and "21" mine of the Port Henry Iron Ore Co. The former company also worked the Sherman and Smith mines on a small scale. The principal feature in the recent history of the district, perhaps, is the increased exploitation of the low-grade or concentrating ores, which are rapidly superseding the richer ores in importance. This has been made possible by the extensive additions to mine equipment that enable a large tonnage to be handled economically and by the erection of large milling plants, of which three are employed at present in the beneficiation of the different mine products. The available ore resources have been greatly increased by these developments and a long life assured for the district.

To facilitate ore shipments from the district, extensive ore docks and loading machinery have been erected at the lakeside at Port Henry, which through the New Champlain and Barge canals has direct water connection with the important furnace centers on the Great Lakes and with the Atlantic seaboard. A fleet of barges is in course of construction by Witherbee, Sherman & Co. and will be employed in transporting the ore to market and in carrying coal or other freight on the return trip.

Cheever mine. This property was again placed in operation, after a shutdown of about two years, and since has been working to

the capacity of the plant. The mine holds the record among the New York magnetite mines in the handling of low-grade ore, as its product for some time has run considerably under 30 per cent in iron, requiring nearly 3 tons crude for a ton of 60 per cent concentrates. Much of the ore treated has come from the floor and roof of the old workings, but there is still available a large area of unworked ground on the northern and southern borders of the exploited territory, enough to assure a supply for many years to come. An increase in the capacity of the plant which now is rated at about 500 tons of crude a day seems justified economically in view of the available tonnage.

Lyon Mountain. The low-phosphorus concentrates from this group of mines find a ready market at a premium over the usual prices and of late have been in special demand. The Chateaugay Ore & Iron Co. is the operator. Plans are being put into effect to enlarge the production. A new shaft with a hoisting capacity of 3000 tons daily has been constructed to take the place of the several small, inconvenient openings that have been used in the past. The principal addition to the surface plant is the mill, on which construction was started during the current season and which when completed will affect considerable economies, as well as provide for a larger outturn, in comparison with the old plant.

Benson Mines. A renewal of operations in these extensive deposits is in prospect for the current season. During 1916 only test runs were made, but it was planned to inaugurate a steady campaign during the present year. The milling plant has been rebuilt, with a change in the method from the dry magnetic concentration practised elsewhere in the Adirondacks to the wet magnetic system similar to that employed largely by the mines of central Sweden. The ore is very dense and close textured, necessitating finer crushing and more careful handling than the common ores of the eastern Adirondacks. Owing to the presence of considerable sulphur, the concentrates also require a roast, which is further beneficial on account of the accompanying agglomeration that takes place. The success of the undertaking will mean a great deal to the iron-mining industry of the State, as the resources in this class of ore are very large.

Jayville. The mines at this place, 14 miles west of Benson Mines, on the Carthage & Adirondack Railroad, were under examination in 1916, with a view to their reopening. They are based on a group of shoots and lenses of magnetite, some of which yield a merchant-

able ore, while others consist of an intergrowth of magnetite with hornblende, biotite and other minerals, forming a lean ore suitable only for concentration. Unlike the Benson Mines deposit they carry little pyrite. The mines were worked last in 1888 by the Magnetic Iron Ore Co., which mined about 25,000 tons in the period of two years in which they were active. The recent work has been undertaken by W. J. Hughes.

Palmer Hill. The exploration of the magnetite bodies at this place near Ausable Forks, Clinton county, has been in progress. The property, as well as many others in this region, was acquired a few years ago by Witherbee, Sherman & Co. with a view to their eventual reopening.

Sterling Lake. A good record was made last year by the two active mines in southeastern New York operated by the Hudson Iron Co. (near West Point) and by the Sterling Iron & Railway Co. at Sterling Lake, just north of the New Jersey state line. Both companies ship their product in lump form, having no concentrating mills on their properties.

The output at Sterling Lake is now taken from a single deposit, known as the Lake, one of the numerous bodies that occur in the vicinity and that together have supported a mining industry for the last 150 years and more. The different deposits vary greatly in their physical features as related to form and content, although situated in the same general geological surroundings, so far as cursory examination shows. Some are thin sheets lying flat, or slightly inclined, others are attenuated lenses with a moderate to steep dip and usually with a pitch to the north, and still others are developed as narrow, elongated shoots with the long axis on the pitch which likewise is to the north. More complex forms result from differential compression and folding of these simpler types.

The principal deposits lie within a belt that begins near the New Jersey line and extends some 5 or 6 miles to and beyond Sterling Lake. It is part of a much larger ore zone that reaches into New Jersey on the south and extends in a general northeasterly direction across Orange county to the Hudson river. Beginning at the south, within a short distance of the state line, the series includes the Steel mine which outcrops on a ridge at about 800 feet A. T. and is based on a band of ore striking N. 20° E. It is opened by a few pits on the south end. The same band of ore extends north beyond the hill under the adjoining valley. The next deposit is the Crawford, located on a lens which begins near the base of the succeeding ridge

and pitches northward under it; it is opened as a pit and underground drift for a distance of 500 feet on the strike. It measures 20 to 50 feet in width from wall to wall, but includes bands of lean or barren gneiss intercalated with the magnetite. An interesting feature of its geology is the presence of massive granite on the eastern or hanging side (the dip is about 75° E.) whereas the foot wall consists of the usual hornblende gneiss. The granite on the north end also caps the ore body.

The California mines are about 7000 feet farther north, on the opposite side of the ridge on which the Sterling and Lake deposits outcrop, and about one-half of a mile distant from these. They are based on a thin but persistent band of magnetite that lies nearly flat and outcrops on the southern and southwestern sides of the hill. The ore is of Bessemer grade, whereas the Lake and Crawford mines contain too much phosphorus to come in that class.

The Sterling and Lake mines, of which the latter is now the only active producer on the property, are opened on two long lenses or shoots which outcrop on the side hill at the foot of the lake and extend north under the latter at an angle of 28° for the Sterling and 23° for the Lake body, measured on the average inclination of the respective slopes. Both dip to the east, although rolls occur which locally reverse the normal dip. The Sterling mine is down 1000 feet and has not been worked since 1902. The Lake slope is over 3200 feet in depth. The two slopes are 500 feet apart at the surface and pursue a slightly divergent course. From the presence of numerous pinches and minor rolls in the Lake mine, it might be reasonably maintained that the two bodies are parts of one original deposit which has been squeezed out into the present form. It seems to be the prevalent opinion locally, however, that they are separate and distinct deposits and the Lake, if it were continued on the dip, would lie above the Sterling deposit. For a distance of 2300 feet on the slope, granite forms the hanging wall of the Lake slope, but at that depth gives way to hornblende gneiss. The Lake mine has yielded 1,500,000 tons of shipping ore up to the present time. The ore runs about 57 or 58 per cent iron and 1 per cent or so of phosphorus.

To the east of Sterling lake about 3000 feet are a series of lenses that lie along a nearly north-south axis, on which are located the Causeway, Mountain and Smith mines. About 800 feet farther east a second series, with openings known as the Augusta, Cook, Scott, Oregon and Long mines, occurs along a parallel axis measuring

6500 feet from south to north. They all have an easterly dip and northerly pitch and have been worked by open cutting or by drifting under cover. The Cook mine, however, was worked through a vertical shaft and had underground connections with the Scott deposit, which also was tapped by a slope. There is little of the early workings in this part now accessible, but the ore as seen in place near the outcrop measures up to 25 feet thick. Altogether the resources still remaining in the various mines are undoubtedly very large since they were worked in early times for the rich ore alone that could be used directly in the furnace, and as a rule all the material that could not be so employed was left in the walls. There is no evidence also that the mines have been bottomed. The ore supply would maintain a large mill for many years.

MINERAL WATERS

The production of mineral and potable spring waters for public sale constitutes an important branch of the mineral industry of the State, though perhaps seldom considered in that light. Not only is a large revenue derived from the bottling and shipment of such waters, but some of the spring localities by virtue of their waters have become favorite resorts for tourists and health-seekers and thus become indirect sources of income of large importance. Saratoga Springs, Ballston Springs, Richfield Springs, Sharon Springs and Lebanon Springs are among the number that will be first called to mind in such connection. They illustrate also the variety of waters which are to be found within the state limits. Saratoga and Ballston yield waters of alkaline-saline character, of wide range of composition. They are further characterized by the presence of carbon dioxide in free state to the extent often of two or three times the volume of the water. The waters are mostly drunk, both for table use and for therapeutic purposes. The application of the highly carbonated waters to bathing has become an important feature of the cure at Saratoga. At Richfield and Sharon the waters are sulphurous and charged with alkalies and alkaline earths. They are employed mainly for bathing. Waters that contain important quantities of sulphur as sulphureted hydrogen, are obtained at Clifton Springs, Massena Springs, and many other localities. Lebanon in Columbia county is the only example of a thermal spring in the State, its water issuing at a temperature of 75°, winter and summer, indicative of a deep source. It is only slightly mineralized,

among the ingredients being small amounts of carbon dioxid and nitrogen.

The sale of potable waters that are not mineralized in the usual sense has become a prominent factor in the industry of late years. Suitable waters for the purpose are obtainable in almost every section of the State, but the industry is mainly centered in the vicinity of the larger towns or points convenient to shipping facilities. The main requirement of such waters is that they be free from contamination and any injurious impurities, in which respect they are usually superior perhaps to the ordinary public supplies. Their sale is extensive in some communities, and altogether the commerce in such waters is greatly in excess of that of the medicinal class.

In 1916 the total sales of mineral waters, as reported by the springs listed below, amounted to 7,746,490 gallons valued at \$697,650. To the total value the table waters contributed \$610,937 and the medicinal waters \$86,713. The returns in 1916 indicated sales of 8,636,920 gallons with a value of \$745,530.

List of springs. The following list includes the names and localities of most of the springs in the State that are employed commercially, as shown by a canvass of the industry:

NAME	LOCALITY
Baldwin Mineral Spring.....	Cayuga, Cayuga county
Coyle & Caywood (Arrowhead Spring)	Weedsport, Cayuga county
Diamond Rock Spring.....	Cherry Creek, Chautauqua county
Cassadaga	Stockton, Chautauqua county
Breesport Oxygenated Spring.....	Breesport, Chemung county
Breesport Deep Rock Water Co.....	Breesport, Chemung county
Chemung Valley	Elmira, Chemung county
Deep Rock	Breesport, Chemung county
Chemung Spring Water Co.....	Chemung, Chemung county
Whiter	Norwich, Chenango county
Dietade	Keeseville, Clinton county
Keeseville Mineral Spring.....	Keeseville, Clinton county
Lebanon Mineral Springs.....	Lebanon, Columbia county
Greendale Crystal Springs.....	Livingston, Columbia county
Mount Washington Spring.....	Hillsdale, Columbia county
Trespur Spring	McGraw, Cortland county
Arlington Spring	Arlington, Dutchess county
Mount Beacon Spring.....	Mount Beacon, Dutchess county
Mount View Spring.....	Poughkeepsie, Dutchess county
Monarch Spring Water Co.....	Beacon, Dutchess county
Elk Spring Water Co.....	Lancaster, Erie county
Aldena Park	Alden, Erie county
Collins	
Diamond Rock	Lancaster, Erie county

Sparkling	Buffalo, Erie county
Oak Mountain	Dolgeville, Fulton county
W. A. A. Heck	Tupper Lake, Franklin county
Eagle Spring	Edgewood, Greene county
White Bear	Batavia, Genesee county
Oasis Cold Spring	, Genesee county
McManus	, Jefferson county
Red Rock	Fine View, Jefferson county
Swan	Alexandria Bay, Jefferson county
Valley	Omar, Jefferson county
Crystaldale	Crystaldale, Lewis county
Nunda Mineral Springs	Nunda, Livingston county
Mohawk Spring	Amsterdam, Montgomery county
Table Rock Mineral	Honeoye Falls, Monroe county
Garden City Well	Garden City, Nassau county
Sagamore	Oyster Bay, Nassau county
Clinton Lithia Springs, Inc.	Franklin Springs, Oneida county
Glen Alix Spring	Washington Mills, Oneida county
Lithia Polaris Spring	Boonville, Oneida county
F. H. Suppe (Franklin Lithia Spring)	Franklin Springs, Oneida county
Orville Risley	New York Mills, Oneida county
Cold	Utica, Oneida county
Paris	Sauquoit, Oneida county
Split Rock Lithia	Franklin Springs, Oneida county
Warner Artesian Well	Franklin Springs, Oneida county
Westmoreland Mineral	Westmoreland, Oneida county
Geneva Mineral Water Springs	Geneva, Ontario county
Orange Great Rock	Middletown, Orange county
Crystal Spring	Oswego, Oswego county
Deep Rock Spring	Oswego, Oswego county
Great Bear Spring	Fulton, Oswego county
Richland	Richland, Oswego county
White Sulphur Spring	Richfield Springs, Otsego county
Black Rock Spring	Rensselaer, Rensselaer county
Mammoth Spring	North Greenbush, Rensselaer county
Shell Rock Spring	East Greenbush, Rensselaer county
Flint	West Sand Lake, Rensselaer county
Ideal	Troy, Rensselaer county
Plymouth	North Greenbush, Rensselaer county
Standard	Troy, Rensselaer county
Carrier	Potsdam, St Lawrence county
Madrid Indian Spring	Madrid, St Lawrence county
Massena Springs	Massena, St Lawrence county
Artesian Lithia Spring	Ballston Spa, Saratoga county
Comstock Mineral Spring	Ballston Spa, Saratoga county
Mohican Spring	Ballston Spa, Saratoga county
Arondack Spring	Saratoga Springs, Saratoga county
Hathorn Nos. 1 and 2 Springs	Saratoga Springs, Saratoga county
Coesa Spring	Saratoga Springs, Saratoga county

Geyser Spring	Saratoga Springs, Saratoga county
Minnonebe Spring	Saratoga Springs, Saratoga county
Orenda Spring	Saratoga Springs, Saratoga county
Saratoga Gurn Spring.....	Saratoga Springs, Saratoga county
Saratoga Vichy Spring.....	Saratoga Springs, Saratoga county
Old Iron	Ballston Spa, Saratoga county
Congress No. 2.....	Saratoga Springs, Saratoga county
Ferndale	Saratoga Springs, Saratoga county
Chalybeate Spring	Sharon Springs, Schoharie county
Eye Water Spring.....	Sharon Springs, Schoharie county
Sulphur-Magnesia Spring	Sharon Springs, Schoharie county
White Sulphur Spring.....	Sharon Springs, Schoharie county
Red Jacket Spring.....	Seneca Falls, Seneca county
Pine Hill Crystal.....	Pine Hill, Steuben county
Pleasant Valley	Rheims, Steuben county
Setauket Spring	Setauket, Suffolk county
Ithaca	Ithaca, Tompkins county
Elixir Spring	Clintondale, Ulster county
Sun Ray Spring.....	Ellenville, Ulster county
Vita Spring	Fort Edward, Washington county
Vermont Mineral Spring.....	Granville, Washington county
Briarcliff Lodge Association.....	Briarcliff Manor, Westchester county
Gramatan Spring Water Co.....	Bronxville, Westchester county
Granite	Granite Springs, Westchester county
Orchard Spring	Yorktown Heights, Westchester county
Mokoho	Mount Kisco, Westchester county
Skenorock	Baldwin Place, Westchester county

MOLYBDENUM

The rare metal molybdenum has for its principal ore the sulphide MoS_2 , which is known as molybdenite. This mineral is found in several places in New York State. The recent extraordinary demand that has developed for the metal in consequence of its application in the manufacture of heavy ordnance, lends interest to every occurrence of molybdenite that has not been inspected and reported upon with reference to its economic possibilities. It is for this reason the accompanying notes upon some New York molybdenite localities have been prepared.

Whitlock¹ lists the following occurrences for molybdenite in his "New York Mineral Localities":

Manhattan Island, between 43d and 44th street and First and Third avenues, found in mica schist; West Point, Orange county, in gneiss; Constitution island (Hudson river off West

¹ N. Y. State Mus. Bul. 70, 1903.

Point), in gneiss; Warwick, Orange county, in limestone; Tilly Foster mine, near Brewster, Putnam county, in serpentine; North Russel, St Lawrence county, gneiss-limestone contact. To this list may be added a locality in the town of New Bremen, Lewis county, reported to the writer by A. F. Buddington; and one north of Peekskill, in Phillipstown, Putnam county, discovered by the writer a few years ago.

Of the above occurrences the one in New York City is no longer accessible. From what has been learned indirectly, it is evident that the West Point, Constitution island, and Warwick occurrences have little or no interest except purely from a collector's standpoint. At the Tilly Foster mine molybdenite occurs sparingly as a contact mineral in the metamorphosed limestone and is no longer to be found except in the waste dumps of the old workings.

The Russel locality, about which little has been made known, was visited during the past summer by A. F. Buddington who contributes the following account of it. The mineral is found in association with a green pyroxene rock, or coccolite, that has been prospected in several places, but rather for copper than molybdenite, according to local accounts. There are few indications of copper, although the rock carries considerable pyrite in thin, lenticular bands. Molybdenite occurs in disseminated flakes and aggregates of flakes, some of which attain a size of an inch or so in diameter and an eighth of an inch thick, but mostly much smaller. The mineral seems to be rather sporadic, and at best too sparsely represented to warrant its mining. The occurrence apparently belongs to the contact type, as the pyroxene wall rock is the result of alteration of limestone and is included in a mass of granite gneiss which undoubtedly has produced the change and introduced the metal. The wall rock is traversed by veins of a coarser pyroxene-phlogopite material which seems to be free of molybdenite. The property on which the prospecting has been done lies just south of Boyd pond, near Russel. It is owned by Martin Leary.

The occurrence in the town of New Bremen, Lewis county, belongs to a different type in that the sulphide is distributed through the mass of a granite intrusion, or rather within indefinitely bordered veins of pegmatite that are found in the granite. The granite has a gneissic appearance and weathers to a reddish color, but is green and pink on fresh surfaces. It may represent a phase of the green syenite found to the northwest of the locality. This occurrence is on the farm of William J. Aucter, three-quarters of

a mile southeast of Bushes Corners, and is reached most conveniently from Croghan, the terminus of a branch railroad from Lowville. Altogether four narrow pegmatite bands were noted, each scarcely more than 1 inch wide, exposed on the face of a sloping ridge for a distance of 25 feet. The flakes are relatively coarse and will average from one-quarter of an inch to one inch in diameter. Traces of the mineral are found at other points along the same ridge. A hill of coarse red gneiss, one-half of a mile south of Stifts schoolhouse, west of the highway, also shows its occurrence. The locality is one that seems to warrant more careful search and possibly some exploration in the hope of uncovering some larger pegmatite veins than those now exposed, which are on the whole fairly rich.

Perhaps the most promising locality of all in respect to actual content of molybdenite in the ore is that on the Owens farm about 5 miles north of Peekskill. The place is just south of the Catskill aqueduct on the west side of Sprout Brook valley. It is now a part of the Stuyvesant Fish estate. The occurrence consists of rusty gneiss which forms a hard ledge traceable for several hundred feet and is made up largely of pyroxene of green color in fresh fracture. The rusty color results from the presence of pyrrhotite that occurs in scattered grains. The rock is of contact nature, an altered limestone undoubtedly, but neither limestone nor granite was noted in the immediate vicinity. It carries disseminated flakes of molybdenite, and in one place so abundantly as to constitute a fairly rich ore, that is containing 2 or 3 per cent of the sulphide. The flakes are small and average scarcely more than one-eighth of an inch in diameter. It would appear that the richly impregnated zone that is now exposed is of small compass, probably only a few feet in diameter. If a considerable body of the ore like that now exposed in the ledge could be found, it would undoubtedly be of commercial importance.

NATURAL GAS

The decline in the production of natural gas that had been under way in the preceding two or three years was checked in 1916 when a campaign of active exploration succeeded in bringing in some new supplies large enough to counteract the material falling off in the older wells. Although a considerable addition to the flow was made, no very important discovery occurred that could be considered as promising a material enlargement of the productive territory. The last event of this kind was in 1912, when the Orchard Park field

of Erie county was opened and brought about the large gain in the yield for that year.

The total flow of natural gas in 1916, according to the reports received from the producers and distributors, was 8,594,187,000 cubic feet, as compared with 7,110,040,000 cubic feet in 1915 and 8,714,681,000 cubic feet in 1914. The figures represented a gain of 21 per cent in the output in the year and put the industry back in nearly the same place it held in 1914. The leading counties on the basis of their output were Erie, Chautauqua, Allegany, Cattaraugus and Genesee.

The value of the production last year was reported as \$2,524,115, against \$2,085,324 in 1915. This is based on the prices received for the gas in the different centers of consumption. The mean for the whole State was 29.4 cents a thousand, the same as in 1915. Actually the prices at which the gas was sold ranged from 20 cents as a minimum to over 50 cents, according to locality. The lowest selling rates were reported in Allegany and Cattaraugus counties, where the local product finds close competition with the Pennsylvania output. The isolated districts of Central New York reported the highest prices which as an extreme, however, were only about one-half those obtained for artificial gas elsewhere.

Production of natural gas

YEAR	OUTPUT 1000 CU. FT.	VALUE	NUMBER OF WELLS
1904.....	2 399 987	\$552 197	.....
1905.....	2 639 130	607 000	.....
1906.....	3 007 086	766 579	.....
1907.....	3 052 145	800 014	925
1908.....	3 860 000	987 775	1 100
1909.....	3 825 215	1 045 693	1 280
1910.....	4 815 643	1 411 699	1 340
1911.....	5 127 571	1 547 077	1 493
1912.....	6 564 659	1 882 297	1 660
1913.....	9 055 429	2 549 227	1 750
1914.....	8 714 681	2 570 165	1 797
1915.....	7 110 040	2 085 324	2 051
1916.....	8 594 187	2 524 115	2 068

For several years it was the practice to report the production according to the counties and leading districts from which the output came. This is no longer possible, as the greater part

of the supply is now handled by a few distributing companies who operate over a large area, often taking in widely separated districts, and who are not always able or willing to distribute their receipts according to locality.

The field reports indicated a total of 2046 wells used for gas on January 1, 1916. A total of 141 new wells were drilled, of which 35 were dry, and 84 old wells were abandoned, so that the number of producing wells at the close of the year was 2068.

Altogether natural gas is produced in 15 counties, situated in the central and western sections between Lake Erie and the east end of Lake Ontario. The most productive fields are in Erie county and include the area east of Buffalo and also many pools in the southern part in the towns of East Hamburg, Aurora, Collins and others. Chautauqua county has over 100 separate producers, most of them small, but with a few large companies which supply their product to local communities. Cattaraugus and Allegany counties contribute considerable quantities of gas, obtained from the same general area as the oil, which is found in several pools along the Pennsylvania boundary. Genesee county has come into prominence in recent years through the Pavilion field in the southeastern corner. Ontario county contains a number of wells, mainly in the towns of East and West Bloomfield. Among the smaller factors in the industry are Livingston, Monroe, Niagara, Onondaga, Oswego, Schuyler, Steuben, Wyoming and Yates. A test well was drilled in 1917 near Belleville, Jefferson county, which found some gas in the Trenton limestone at 600 feet depth. Similar discoveries are reported from time to time in the limestones and shales along the Mohawk valley as far east as Albany county, but there have never been any commercial pools developed anywhere east of Oswego county, which contains some small but persistent and paying wells in the vicinity of Pulaski and Lacona.

The business of distributing the output among the cities and towns within the different districts is controlled by a relatively small number of concerns, some of whom are engaged also in productive operations. The Iroquois Natural Gas Co. of Buffalo, the largest single distributor in the State, operates pipe lines to the principal fields in Allegany, Cattaraugus, Erie and Genesee counties. The Alden-Batavia Natural Gas Co. and the Pavilion Natural Gas Co. are important producers and distributors in the Erie-Genesee county districts. In Chautauqua county the larger operators are the Frost Gas Co. and the Silver Creek Gas & Im-

provement Co. In Allegany and Cattaraugus counties the Gowanda Natural Gas Co., the Empire Gas & Fuel Co. and the Producers Gas Co. are important. In Ontario county the main producer and distributor is the Ontario Gas Co. Among the smaller companies engaged in the business are the Consumers Natural Gas Co. with wells in the town of Darien, Schuyler county, the Baldwinsville Light & Power Co. of Baldwinsville, Onondaga county, the Pulaski Gas & Oil Co. of Pulaski, Oswego county, and the Sandy Creek Oil & Gas Co. of Sandy Creek, Oswego county.

PETROLEUM

The production of petroleum in 1916 fell a little short of the usual average, for which the decline in prices in the previous season and the resulting discouragement of new drilling may be held partially responsible. The total pipe-line receipts were 874,087 barrels, as compared with 928,540 barrels in 1915 and 933,511 barrels in 1914. A gradual falling off in the production, furthermore, has to be expected; no new oil pools are being discovered to take the place of those now drained nearly dry after many years of steady output. There is still left some undrilled territory in the Allegany and Cattaraugus county fields and its development will keep the industry alive for some time to come.

The progress of drilling from year to year depends largely upon the encouragement that is received from the market. The new wells can be depended on for a yield of one or two barrels a day as a rule, but rarely more. Consequently it is unprofitable to carry on the work when prices are low, which for New York crude means considerably more than the general average of quotations. When prices fall below \$2 a barrel for New York crude there is little profit in production. The trend of quotations in 1915 was downward during the first half, starting at \$1.50, and then a gradual rise began, persisting to the end when the price reached \$2.25 a barrel. In 1916 the course of the market was upward during most of the twelvemonth. At the start the price was \$2.25, the same as in the preceding December, but in February an advance to \$2.35 took place, to be followed in March by a further raise to \$2.50 and in April by another to \$2.60 a barrel. The market remained at this level during May and June. In July a decline to \$2.35, with a further recession to \$2.30 in August, brought an interruption to the usual trend. In September the price advanced to \$2.50. A sharp rise to \$2.75 came in November, followed by

still another increase to \$3.05 in December, the highest mark reached in recent years.

The number of new wells drilled during the year was larger than in 1915 but still fell below the average.

Production of petroleum in New York

YEAR	BARRELS	VALUE
1897.....	1 279 155	1 005 736
1898.....	1 205 250	1 098 284
1899.....	1 320 909	1 708 926
1900.....	1 300 925	1 759 501
1901.....	1 206 618	1 460 000
1902.....	1 119 730	1 530 852
1903.....	1 162 978	1 849 135
1904.....	1 036 179	1 709 770
1905.....	949 511	1 566 931
1906.....	1 043 088	1 721 095
1907.....	1 052 324	1 736 335
1908.....	1 160 128	2 071 533
1909.....	1 160 402	1 914 663
1910.....	1 073 650	1 458 194
1911.....	955 314	1 251 461
1912.....	782 661	1 338 350
1913.....	916 873	2 255 508
1914.....	933 511	1 773 671
1915.....	928 540	1 476 378
1916.....	874 087	2 190 195

The statistics of production for the 20-year period 1897-1916 are shown in the accompanying table. The figures up to the year 1903 are those published in the annual volumes of the *Mineral Resources* while for the remaining years the statistics have been collected directly from the pipe-line companies and shippers who operate in the New York fields. For 1916 a canvass of the individual producers was carried out by the United States Geological Survey and the New York State Survey in cooperation, which showed a total of 11,200 wells in production at the close of the year. The wells were distributed as follows: Allegany county, 7794; Cattaraugus county, 3183; Steuben county, 223.

From time to time efforts are made to extend the limits of the oil-bearing territory by drilling to the northward and eastward of the productive area. The results occasionally have seemed successful at first, as oil in some quantity has been encountered in such experiments. A few years ago a good deal of excitement

was aroused by the bringing in of a well in the extreme northern part of Allegany county, near the Livingston county line, in the so-called Granger field. The oil at first flowed under natural pressure. In the boom that followed some 30 wells were drilled in the vicinity, but the supply was quickly exhausted and less than 3000 barrels in all were produced. Another discovery was made in the vicinity of Swain in the same county, with similar results. The attempt to develop oil in the region to the east of the proved territory has been scarcely more successful. So far no persistent pools have been tapped much east of the Allegany-Steuben county line. A well was recently drilled near Adrian, in the town of Canisteo, Steuben county, that is reported to have encountered oil at 625 feet in shale. The oil was of canary yellow color and high in the light distillates. At the start it produced 14 barrels a day, much better than the average in the old territory, and attracted wide attention. The flow soon ceased.

PYRITE

In its resources of sulphur ores, New York State has an asset which is not as yet fully appreciated. The deposits have been little exploited up to the present, although for a number of years they have shared with those of one or two other states the principal rôle in the domestic industry, which, it need scarcely be remarked, has never measured up to the needs of the home market. In sulphur content they are low grade, so that the ores have to be concentrated before shipment, but they are extensive, well located for convenience of mining and milling, and have the advantage of ready accessibility to the leading centers of acid manufacture on the Great Lakes and Atlantic seaboard.

In the present situation which portends a probable scarcity of pyrite in the immediate future, if not an actual dearth of material available for acid making, the resources of New York deserve consideration for the possibilities they hold of increased utilization.

The deposits that are of most importance, present and prospective, occur on the west side of the Adirondacks in St Lawrence and Jefferson counties. The region is underlain by the same Precambrian rocks as the Adirondacks, but has a moderate altitude, only 500 to 800 feet A. T., and low relief. In a way it bridges the gap between the Precambrian area of northern New York and the Laurentian province of Canada, here separated only by the width of the St Lawrence plain. The region is noted for its agricultural wealth, no less than for its varied mineral character.

The pyrite, associated with more or less pyrrhotite, occurs in certain well-defined belts of Grenville gneiss, of which the more important have been recently mapped by A. F. Buddington for the State Geological Survey. There are at least 9 or 10 individual belts, so far known, distributed over the region, but those of most interest from a mining standpoint are grouped within a single zone that stretches from the town of Canton in the central part of St Lawrence county southwest for some 40 miles to and beyond Antwerp in Jefferson county. The developed deposits all lie in this zone; they include the Pyrites and Stella mines near the north-eastern extremity, both with abundant resources, the Cole mine opened in a large ore body near the center, and several others which are to be classed as prospects so far as exploration is concerned, but with the appearance of substantial deposits.

All the deposits possess a certain similarity in their physical surroundings and mineral character, however much they may differ in the details of form, size or content. They are associated with one of the characteristic Grenville rocks (a banded rusty gneiss) which varies in individual layers or beds from a quartz-feldspar-biotite gneiss to nearly pure quartzite and not infrequently contains intercalations of crystalline limestone. The rock occurs in belts that extend northeast and southwest, usually for distances of several miles, but of narrow width. Careful study of the field features has revealed that these belts are parts of a single series of beds repeated by folding, the strata having been tightly compressed and overturned so as to give a common inclination to all, the dip being almost invariably northwest and usually at a high angle. In outcrop the gneiss is distinguished by its rusty burnt look which shows the presence of sulphides, and where concealed its occurrence is denoted by the red color imparted to the soil. The gneiss with its disseminated pyrite is much like the "fahlbands" that are described in connection with metalliferous veins in the crystalline schists, whereas the concentrated pyrite that constitutes the deposits proper may be likened to the veins themselves.

The workable bodies partake of the tabular form of the gneiss, to the structure of which they conform very closely. Their parallelism with the foliation of the gneiss, the general similarity between the ore and wall rock so far as qualitative mineral composition is concerned, and the indefinite contacts seem at variance with the idea of a secondary derivation for the sulphides but rather argue for their primitive accumulation with the sedimentary wall rocks. On

the other hand C. H. Smyth jr.¹ who has given most attention to the origin of the ores, shows that the pyrite in large part is undoubtedly of later crystallization than the gangue and that the only difference between the workable deposit and the country rock is the degree to which the metasomatic process has been carried. In evidence of such derivation may be pointed out the abundance of secondary minerals, chiefly chlorite, developed as an accompaniment of the process. It is noticeable also that graphite is always associated with the ores, in a manner suggestive of precipitating action upon the metallic ingredients.

In most examples of the ore the pyrite may be seen to occur in two forms: as finely divided particles more or less evenly distributed through the gangue and as aggregates of coarser grains and crystals in bunches, veinlets and stringers of quite irregular distribution. The relative abundance of the latter type determines to a great extent the relative richness of the ore. Pyrrhotite is not uncommon, but much less abundant than the pyrite. It forms independent bodies and also occurs in a few places in association with the pyrite. Its distribution seems entirely without rule.

Analyses of representative samples taken from various parts of the district show that the sulphur content ranges between the approximate limits of 20 and 30 per cent for the most part. The samples on which they were based were taken so as to give, so far as practicable, a fair average of the ore in a working face or exposure. The results are in agreement with mining experience in the district. Ore carrying around 30 per cent has been shipped in some quantity from the Cole property, and the average of that mine is probably over 25 per cent. The Stella and Pyrites deposits are lower grade, with an average of 20 per cent or a little more.

Experience has shown that the ores will concentrate readily to about 45 per cent sulphur, for which something over 2 tons crude will be required, depending on the individual deposit.

Of the three properties which have been exploited on a commercial scale, the Stella is the single one in present operation. It is worked by the St Lawrence Pyrite Co. and turns out 50,000 tons or more of concentrates a year. The Cole mine, which has been worked intermittently, shipping lump ore, was taken under option by the same company during the past summer and explored. It has an ore richer than the average. The third mine, known as the Pyrites or High Falls, is held on lease by the Oliver Iron Co., of

¹ N. Y. State Mus. Bul. 158, 1912.

Duluth, which has never worked it but apparently is holding the property as a possible future source of supply.

In addition to these developed mines there are many prospects and outcrops of the pyrite ores in southwestern St Lawrence and northern Jefferson counties. The beltlike development of the pyritous schists makes for a degree of continuity in the ore-bearing areas as they are traced on the strike that is quite remarkable, although of course there is no absolute uniformity in the enrichment of the material by sulphides. At the same time the work of prospecting is greatly facilitated by this characteristic.

The same belt in which the Cole mine is located extends northeast for 6 or 7 miles, paralleling the Rome, Watertown & Ogdensburg Railroad for the first 5 miles to a point a mile or so beyond Bigelow. The Hendricks, Styles and Farr shafts are located within this area.

Another belt extends through Hermon and has been prospected near Ore Bed school, 2 miles northeast of Hermon village.

A remarkably persistent outcrop of the pyrite schist is found in the towns of Hermon, Fowler and Gouverneur, St Lawrence county, and Antwerp, Jefferson county. It crosses the Oswegatchie river at Hailesboro, from which point it reaches northeast in a nearly straight course to the Barnum school, in the town of Hermon, and southwest to Keene station below Gouverneur and thence along the Rome, Watertown & Ogdensburg Railroad to near Antwerp. Its principal development is in the stretch from near the old Caledonia iron mines just north of Keene to the Dickson mines north of Antwerp. The pyrite schist is accompanied in this stretch by hematite which also occurs in sporadic bodies elsewhere and which is an indicator of pyrite throughout this section. Little or no prospecting for pyrite has been carried on in this belt, although the schist has been well exposed by the iron-mining operations or is found in natural outcrop. In several places, notably on the Keene, Morgan, Wight and Dickson properties, there is a good body of the ore shown which carries above 20 per cent in sulphur. The vein ranges from 10 to 25 feet or more in thickness. The deposit is so persistent on the surface that its continuity for a good distance on the dip may be regarded as assured. The ore is coarser in grain in the southwest part on the Wight and Dickson properties than elsewhere. With the railroad close at hand this section seems one of the most attractive in which to prosecute exploration for pyrite.

In the vicinity of Oxbow, Jefferson county, is another schist belt that has locally enriched bodies that carry around 25 per cent or

more sulphur. The Laidlaw farm, 1 mile east of Oxbow, on the north end of the belt, has been prospected in a small way by trenching across the body in one or two places. The ore shown in the principal pit consists of 4 feet of pyrrhotite on the footwall with 15 to 20 feet of pyrite overlying it. A composite sample of the latter gave the following results on analysis: Sulphur, 29.06 per cent; arsenic, 0.22 per cent; iron, 33.77 per cent. A sample of the pyrrhotite from the same place yielded 27.78 per cent sulphur.

In the vicinity of Sylvia lake is a belt of pyrite schist on which some prospecting has been done. The Kilburn place is one of the localities that has been tested. In the average the ore is lower grade than that of the other belts described. The belt is also rather inaccessible, lying several miles distant from the nearest station on the Edwards branch railroad. A very similar grade of ore occurs, south of Talcville, near Pleasant Valley school.

Altogether the St Lawrence-Jefferson county region contains enormous resources of ore of low-grade character. All of the material requires concentration to bring it up to marketable standard. The ratio of concentration and tenor of the product obtainable under practical conditions can be determined of course only by actual tests conducted for each deposit. But the experience that has been obtained in the past at the several mines under operation may be taken as a useful guide in a general way. It would appear that the practical limit to which concentration may be carried with the ores is to produce a product with 45 to 47 per cent sulphur. This requires from 2.5 to 3 tons of the crude 20 to 25 per cent ore to each ton of concentrates. Mining conditions in the region on the whole are favorable. The costs for mining and milling may be taken as about on the same level as in the iron mines in the eastern Adirondacks, or a little below the latter if anything, due allowance being made for local conditions and surroundings of the currences.

SALT

The salt industry experienced a remarkable expansion of activity in 1916. Although no new mines or evaporating plants entered the list of producers during the year, the output increased by about 27 per cent in quantity and 23 per cent in value as compared with the totals reported for 1915. This shows the great reserve of productive capacity available that was not hitherto brought into use.

The total product, inclusive of rock and evaporated salt and the salt contents of brine employed for the manufacture of soda products, amounted to 14,087,750 barrels, as compared with 11,095,301 barrels for the preceding year, also a record output. It is noticeable

that the value placed upon the product, \$3,698,798, represents a smaller average than the amount \$3,011,932 returned for 1915, the value a barrel being 26 cents last year, against 27 cents in 1915. In spite of this the actual selling prices of marketed salt showed a considerable increase, as will be observed from the figures given in the accompanying tables. The explanation of the apparent anomaly lies in the proportionately larger output of salt in brine used for chemical manufacture without evaporation, on which a merely nominal value is placed and which in consequence of the size of the product has a very appreciable influence upon the average figure. The grades of evaporated salt, which naturally command the highest prices in the market, account for only about 25 per cent of the total product of the State. The prices for such grades ranged last year between 44 and 71 cents a barrel, as compared with an average of 16 cents for the combined output of rock salt and salt in brine.

Production of salt by grades in 1915

GRADE	BARRELS	VALUE	VALUE A BARREL
Common fine <i>a</i>	I 460 379	\$598 193	\$.40
Common coarse.....	126 193	59 077	.46
Table and dairy.....	I 274 743	829 581	.65
Solar.....	267 886	93 760	.35
Packers.....	165 179	83 890	.50
Other grades <i>b</i>	7 800 921	I 347 431	.17
Total.....	II 095 301	\$3 011 932	\$.27

Production of salt by grades in 1916

GRADE	BARRELS	VALUE	VALUE A BARREL
Common fine <i>a</i>	I 694 943	\$828 617	\$.48
Common coarse.....	267 421	153 844	.57
Table and dairy.....	I 308 529	940 969	.71
Solar.....	249 728	110 505	.44
Packers.....	<i>c</i>		
Other grades <i>b</i>	IO 567 129	I 664 863	.16
Total.....	14 087 750	\$3 698 798	\$.26

a Common fine includes a small amount of common coarse.

b Includes rock salt, salt in brine used for alkali manufacture, agricultural salt and small amounts of brine salt for which the uses were not specified in the returns.

c Included in other grades.

In respect to the separate items of the tables, it may be noted that common fine salt includes the commercial product of fine artificially evaporated salt, not specially prepared for use. Common coarse is the coarser product of similar quality. Table and dairy salt represents the highest grade, specially sorted or otherwise prepared for table and dairy use. Packers is the grade sold to meat packers and fish salters. Solar salt is a somewhat exceptional product, as it is made in no other state in the east, and it does not compete in the market with other grades of evaporated salt. It represents the output of solar evaporation of the natural brines that occur in Syracuse and vicinity. Its uses are much the same as those of rock salt.

The returns for 1916 showed a total of 25 active concerns in the business in the State, distributed among the following counties: Genesee 1, Livingston 3, Onondaga 15, Schuyler 1, Tompkins 2, Wyoming 3. Of the number, 14 were solar salt makers with a small individual output. Two produced rock salt and the other 9 were engaged in making various grades of evaporated salt. Livingston county has the largest output, followed closely by Onondaga, with Tompkins in third place.

Following the recent exploration at Portland Point, Cayuga county, announced in the report for 1915, which resulted in the location of a bed of rock salt 65 feet thick at a depth of 1484 feet from the surface, shaft sinking operations were begun with a view to working the salt deposit underground. Operations were held up during a part of the year by trouble with natural gas, which resulted in a serious explosion and incident loss of life. The flow of gas came mainly from the Marcellus shale, according to accounts, and there seemed to be no reason to anticipate that the difficulties from this source would increase with depth so as to endanger the final success of the undertaking.

The following table of production for the 20-year period 1897-1916 evidences the rapid strides that have been made in the development of the local resources. The figures for the years preceding 1904 are taken from the volumes of the *Mineral Resources*, published by the United States Geological Survey.

Production of salt in New York

YEAR	BARRELS	VALUE
1897.....	6 805 854	\$1 948 759
1898.....	6 791 798	2 369 323
1899.....	7 489 105	2 540 426
1900.....	7 897 071	2 171 418
1901.....	7 286 320	2 089 834
1902.....	8 523 389	1 938 539
1903.....	8 170 648	2 007 807
1904.....	8 724 768	2 102 748
1905.....	8 575 649	2 303 067
1906.....	9 013 993	2 131 650
1907.....	9 657 543	2 449 178
1908.....	9 005 311	2 136 736
1909.....	9 880 618	2 298 652
1910.....	10 270 273	2 258 292
1911.....	10 082 656	2 191 485
1912.....	10 502 214	2 597 260
1913.....	10 819 521	2 856 664
1914.....	10 389 072	2 835 706
1915.....	11 095 301	3 011 932
1916.....	14 087 750	3 698 798

SAND AND GRAVEL

The sand and gravel industry is represented in every section and nearly every county of the State. The deposits of these materials are so widespread that usually the ordinary demands of each community, so far as building purposes are concerned, can be met from supplies close at hand.

The sand and gravel beds of the State belong mainly to the Pleistocene formations, accumulated as the result of the great ice invasion which moved from north to south and reached as far south as northern New Jersey and Pennsylvania. This ice sheet swept the rocks bare of their former mantle of disintegrated material and in its place left a covering of transported boulders, gravels, sands and clays. These deposits, when laid down directly by the ice as ground moraine, are so intermixed as to have little or no industrial value. Such unmodified drift covers a considerable portion of the area, especially of the hilly country; in the valleys and lowlands the ground moraine has been removed by stream action or concealed below beds of sorted gravels and sands that were laid down in bodies of standing water whose existence in most cases was incidental to the flooded waters of the Glacial period. In some of

the larger valleys like the Hudson, Champlain and Genesee, as well as in numerous smaller ones, the glacial waters were held imprisoned for a time by dams so that they stood high above the present levels, and the sands and clays are revealed today in a series of terraces of great thickness and well-sorted arrangement.

Beach sands are found on the shores of many of the interior lakes and around Oneida lake in particular are of considerable economic importance. These are characterized by a degree of uniformity and purity which make them valuable for many purposes, like glass-making, molding, etc. The most valuable sand beaches, however, occur on Long Island where most of the supply of building sands for New York and vicinity is obtained.

The information as to the production of sand and gravel collected for this report gives probably a fairly close approximation of the business, and for certain branches is very reliable, but it is not claimed that it is complete. The figures for building sand and gravel are perhaps the least reliable, and understate the actual business perhaps as much as 15 per cent of the total output in any one year. The operations in building sand are so widely scattered and often of so fugitive nature that it is impossible to keep abreast of all the developments and changes in the industry that take place. On the other hand, the data on molding sand are measurably full and the statistics can be accepted as being as accurate as those in many other lines of the mineral industry. This branch of the trade has a stable basis and is restricted to a limited area, mostly in the Hudson River valley.

Production of sand and gravel

MATERIAL	1914	1915	1916
Building sand.....	\$1 151 521	\$1 185 812	\$941 884
Molding sand.....	310 727	415 073	570 898
Fire and core sand.....	23 944	24 797	16 430 ^b
Other sand <i>a</i>	75 000	75 000	134 638
Gravel.....	650 895	965 336	980 979
Total.....	\$2 212 087	\$2 666 018	\$2 644 829

a Includes engine sand, paving, glass, railroad ballast and a small amount of miscellaneous sand.
b Represents fire sand alone.

The total quantity of building sand (for concrete and mortar) reported in 1916, for which the value alone is given in the above

table, was 4,331,603 short tons. In the preceding year the compilation was based on cubic yards, of which the reported quantity was 4,127,508, equivalent to about 5,000,000 tons. The drop in the production thus shown was owing to the dulness of the building trade, a condition that obtained all over the State as the result of the general situation brought on by the war. Nassau county, from which the New York market derives its supply, produced 3,044,359 tons valued at \$578,945. The industry there is controlled by a few corporations who dredge the sand from shallow waters or excavate it by steam shovels from the exposed beaches. The sand is screened and loaded onto barges for shipment.

The output of molding and core sand in 1916 was 661,673 short tons valued at \$570,898, against 454,511 short tons worth \$415,073 in the preceding year. The business experienced a decided improvement, compared with the conditions in 1915, from the extraordinary activity in the metal industries. Most of the molding sand comes from the Hudson valley, from Rensselaer and Saratoga counties on the north to Dutchess and Ulster counties on the south. The material represents a special form of the fine sands, which with the brick clays, were laid down in the expanded waters that occupied the valley at the close of the ice invasion. The molding sand layer consists of the uppermost weathered layer from a few inches to several feet thick.

Among other kinds of sand that were produced in the State may be mentioned abrasive and grinding sand, 169,737 short tons, valued at \$46,900; fire or furnace sand, of which the output amounted to 38,144 short tons, valued at \$16,430; engine sand, 66,497 short tons, valued at \$30,144; paving sand, 83,671 short tons, valued at \$29,282; and various other uses 17,862 short tons, valued at \$5,325.

The production of gravel for roofing, concrete and other uses amounted to 2,728,910 short tons, of a total value of \$1,003,966.

STONE

The stone industry has for many years occupied a prominent place among the branches of the mineral industry of the State. Its growth was particularly rapid in the decade from 1890 to 1900, which was a period of remarkable advancement in all kinds of engineering work. At about the latter date, however, certain changes began to be introduced in the methods of building and

engineering construction that served to check the rapid development of the stone industry and partially to transform it. The use of cement and terra cotta first gained importance about that time and has steadily expanded in the subsequent interval, largely at the expense of cut stone. This branch of the trade, consequently, has declined to small proportions, whereas formerly it was one of the principal elements in the industry and probably the most profitable one. Similarly the market for flagstone and curbstone has fallen off, especially flagstone, as a result of the favor shown for cement in street work. As a partial counterbalance for these losses, a tremendous development has occurred in the crushed stone trade through the requirements of concrete construction and road improvement work; yet altogether the changes that have occurred have meant a loss industrially, since in place of the numbers of skilled workmen once employed in the business there is now a minimum of hand labor, and much of it untrained.

The year 1916 brought little change in the conditions of the stone trade from those of the preceding year which were regarded as unsatisfactory. In one or two branches some improvement was noted, sufficient to give a slight impetus to the productive activities which were on a little larger scale than in 1915. The aggregate value of the quarry materials for the year was \$5,979,622 against \$5,162,115 in 1915 and \$5,741,137 in 1914. There was thus a gain of about 16 per cent in the output for the year, but an increase of only 4 per cent for the two years. It is not unlikely that the turning point in the downward trend has been passed and that conditions will hold the slight gain already made, if they do not actually show further improvement.

The record of the industry for the last three years is exhibited in detail in the accompanying tables.

The granite quarries have continued to operate at about the usual rate. A large share of the product is building stone and is supplied on contract. A considerable gain in the output in 1916 under the last item of the table is accounted for by the restarting of some paving block quarries.

Limestone accounted for considerably more than one-half of the total value last year. Its importance lies mainly in its extensive use for crushed stone, for which limestone is by far most extensively employed.

Marble showed a gain, contributed by the building and monumental branches, which more than made up for the falling off in 1915. There are only a few quarries active in this industry.

Sandstone is the one variety which has experienced an almost uninterrupted decline during the last decade. More than any other kind it has felt the competition of cement, since the principal branches in New York State are those supplying stone for street work — curbstone, flagstone and paving blocks.

A gain in the production of trap restored the loss registered in the preceding year. The industry is carried on chiefly in Rockland county, and the principal quarries are in process of condemnation as part of the plan for the conservation of the Palisades.

Production of stone in 1914

VARIETY	BUILD- ING STONE	MONU- MENTAL	CURBING AND FLAG- GING	CRUSHED STONE	ALL OTHER	TOTAL VALUE
Granite.....	\$79 903	\$10 952	.....	\$259 750	\$16 637	\$367 242
Limestone.....	81 409	.....	\$3 877	2 156 503	1 074 274	3 316 063
Marble.....	142 223	70 797	.....	8 000	9 222	230 242
Sandstone.....	217 508	.....	490 222	36 143	313 117	1 056 990
Trap.....	.....	.....	.....	770 600	.....	770 600
Total.....	\$521 043	\$81 749	\$494 099	\$3 230 996	\$1 413 250	\$5 741 137

Production of stone in 1915

VARIETY	BUILD- ING STONE	MONU- MENTAL	CURBING AND FLAG- GING	CRUSHED STONE	ALL OTHER	TOTAL VALUE
Granite.....	\$261 091	\$19 926	\$1 165	\$61 965	\$78 450	\$422 597
Limestone.....	63 121	.....	1 627	2 072 852	1 040 100	3 177 700
Marble.....	61 601	37 074	.....	.....	21 772	120 447
Sandstone.....	198 743	.....	317 986	77 368	296 314	890 411
Trap.....	.....	.....	.....	497 660	53 300	550 960
Total.....	\$584 556	\$57 000	\$320 778	\$2 709 845	\$1 489 936	\$5 162 115

Production of stone in 1916

VARIETY	BUILD- ING STONE	MONU- MENTAL	CURBING AND FLAG- GING	CRUSHED STONE	ALL OTHER	TOTAL VALUE
Granite.....	\$173 431	\$9 293	.....	\$55 196	\$130 199	\$368 119
Limestone.....	59 492	<i>a</i>	\$1 621	2 085 748	1 525 593	3 672 454
Marble.....	133 238	75 587	.....	.....	59 566	268 391
Sandstone.....	184 971	.....	259 047	124 555	145 985	714 558
Trap.....	4 000	.....	.....	952 100	.....	956 100
Total.....	\$555 132	\$84 880	\$260 668	\$3 217 599	\$1 861 243	\$5 979 622

a Included under "all other."

GRANITE

The quarrying of granite for commercial purposes is carried on in the Adirondack and St Lawrence river regions in the north and the Highlands in the southeastern part. A detailed account of the resources in this material, which are much more important than one might infer from the statistics of production, will be found in Bulletin 181 of the New York State Museum, issued in 1916.

The granite employed for building stone is mainly quarried in southeastern New York. The Mohegan Granite Co., with quarries near Peekskill, and the firm of H. S. Kerbaugh, Inc., with quarries at Valhalla, are the principal factors in this industry. The Peekskill stone possesses an attractive appearance in the mass, being from light gray to deep yellow in color. The yellow variety has been much in demand for large structures.

In the Adirondacks, Essex and Clinton counties contribute most of the stone reported from that region. Included in the product is the green monumental stone from Ausable Forks, scarcely to be duplicated elsewhere. The material is really syenite and is very lustrous when polished, showing a dark green color.

In the St Lawrence River district the Wisconsin Granite Co. has recently acquired interests in quarry lands of the well-known red granite which outcrops on several islands in the river. Its main quarries are on Wellesley island, which were worked last year for paving blocks. J. Leopold & Co. have quarries at Alexandria Bay, where paving blocks are the main product. The output of this region is sold in the markets contiguous to the Great Lakes.

The output of granite in 1916 had a value of \$368,119, as compared with \$422,597 in 1915. The value of the building stone was \$173,431, against \$261,091 in the preceding year. Monumental stone accounted for a value of \$9293 (\$19,926 in 1915) and crushed stone for \$55,196 (\$61,965 in 1915). The output of paving blocks was valued at \$44,437. Rubble and riprap represents a value of \$81,412.

LIMESTONE

The stone classified under the heading of limestone consists for the most part of the common grades of limestone and dolomite, such as are characterized by a compact granular or finely crystalline texture and are lacking in ornamental qualities. A smaller part is represented by crystalline limestones and by the waste products of marble quarrying which are sometimes employed for crushed stone, lime-making or flux. Limestone used for the manufacture of portland and natural cement is, however, excluded from the tabulations so as to avoid any duplication of the statistics.

Limestones have a wide distribution in the State, the only region which is not well supplied being the southern part, where the prevailing formations are sandstones of upper Devonian age. The micro-crystalline varieties occur in regularly stratified order in the Cambrian, Lower Silurian, Upper Silurian and the lower and middle parts of the Devonian system. In most sections they occupy considerable belts and have been little disturbed from their original position. On the borders of the Adirondacks and in the metamorphic Hudson River region, however, they have been more or less broken up by faulting and erosion and in places have a very patchy distribution.

The main limestone formations of the State are the Beekmantown, developed in the Champlain and Mohawk valleys, usually rather impure and hence not very important economically; the Chazy limestone in the Champlain valley, with its time equivalent the Pamela limestone in Jefferson county, one of the highest grade calcium limestones in the State and suitable for nearly all purposes, even being employed as ornamental stone by reason of its attractive color and the ornamental pattern it takes on in polished condition, from the presence of fossils; the Trenton limestones which include the several members known as the Lowville, Black River and Trenton, developed on the eastern, southern and western sides of the Adirondacks, extensively employed for cement, lime, flux and various structural uses; the Niagara beds, mainly represented in the

western part between the Genesee and Niagara rivers, including dolomite with minor beds of calcium limestones; the Cayuga group of the eastern and central parts; the Helderbergian limestones, strongly represented in the Hudson valley from Albany county to Ulster county, employed in portland cement manufacture, lime-making and structural purposes; the Onondaga limestone, developed from the Niagara river across the State to Albany county and thence through Greene, Ulster and Orange counties to the Delaware river, probably the most extensively quarried of all; and the Tully limestone, a relatively thin formation extending from Ontario to Madison county, used by the cement works at Portland Point on Cayuga lake. In addition to the hard limestones there are beds of marl or earthy carbonate of lime in many parts, particularly in the lower ground which are or have been occupied by swamps and lakes.

As has been noted in a previous paragraph, limestone takes first place among the kinds of stone represented in the production of the State. In value it constitutes considerably more than one-half of the total, although for some uses it ranks far inferior to other kinds. Its main use is as crushed stone for concrete and road work; material for such purpose may be had from practically all the formations that contain these rocks. It also finds extensive employment for chemical and metallurgical purposes, serving as reagent in numerous ways. Lime manufacture still holds a prominent place in the industry, although it has felt the competition of cement and gypsum plasters. Of late a growing demand has been felt for ground limestone and for burnt lime in agriculture. As a building stone limestone is of secondary importance.

The production of limestone in 1916 increased somewhat, the value \$3,672,454 comparing with \$3,177,700 in the preceding year, which also was smaller than in 1914.

The output of crushed stone was returned as 3,612,177 tons, valued at \$2,085,748. Of this the quantity used for road purposes was 1,566,530 tons, with a value of \$903,350, that for railroad ballast 891,118 tons valued at \$494,858, and the quantity for concrete was 1,154,521 tons valued at \$687,540. In 1915 the quantity was reported in cubic yards, each cubic yard representing about one and one-fourth tons, and the total for all kinds was 2,985,347 yards, valued at \$2,072,852.

Building stone, rough and dressed, was returned at a value of \$59,492, against \$63,121 in the preceding year. The decline was

small but was a continuance of the trend that has been maintained for several years past; the total was scarcely one-third that of 10 years ago, so rapidly has this branch of the business fallen off.

The quantity of stone quarried for furnace flux was reported as 657,788 tons valued at \$405,774. In 1915 the quantity was 822,729 short tons with a value of \$440,237. This material largely consists of high-calcium limestone, and to meet the requirements the stone has to be quite low in silicious and aluminous ingredients, and contain little or no phosphorus or sulphur. The large flux quarries are in the Onondaga limestone of Erie and Genesee counties; the Clinton limestone of Niagara county; the Chazy limestone of Clinton county; and the Precambrian crystalline limestones or marbles of the Adirondack region.

Lime manufacture is still one of the larger outlets for the product, although the business has undergone considerable change in the last few years. Building lime, formerly the most important branch of the business, has only a limited market now, with the general use of cement and gypsum plasters; on the other hand various other uses have developed to take its place. The paper mills afford a large market for the product, and one of the most profitable, since the local burners command certain advantages from their situation near the markets. The recent campaign for the improvement of farm lands has brought about a large increase in the amount of lime employed as an amendment, though there is still a great field for further development along this line. Metallurgy is another outlet of growing importance. The curtailment of supplies of magnesite has caused manufacturers of refractory materials to turn to dolomite as a substitute. The State has ample resources of this material. The statistics of the industry for 1916 show a total output of lime amounting to 117,490 short tons with a value of \$636,668, which represented a large gain in the business. The principal centers of the industry are in Warren, Washington, Clinton, Fulton, Lewis and Dutchess counties.

Ground raw limestone for agricultural uses was reported to the value of \$164,237. This would correspond to about 80,000 tons, which is probably somewhat short of the actual sales in that form.

MARBLE

True marble is a thoroughly crystalline limestone, in which the carbonates are developed as more or less equidimensional rhombohedra. Such form of limestone results from the crystallizing

influence of heat and pressure and consequently is found in metamorphic areas that accompany mountain-making and igneous intrusions. In New York State this form occurs in the Adirondacks in the north and the Taconic-Highlands region in the southeast. It is thus of early geological age, since the period of crustal movement and metamorphism in the Adirondacks was terminated before the beginning of Cambrian time, and in southeastern New York was completed with the Paleozoic.

In the Adirondack region the crystalline limestones useful for quarry materials are most abundant on the western border in Jefferson, Lewis and St Lawrence counties where they occur in belts up to 4 or 5 miles wide and several times that long, interfolded and more or less intermingled with sedimentary gneisses, schists and quartzites. They are found in smaller and more irregularly bounded areas in Warren and Essex counties on the eastern side, but have little importance elsewhere. The serpentinous marbles that have been quarried at different times belong to the same series. The marbles of the Adirondacks comprise both calcite varieties with little magnesia, and magnesian varieties ranging into true dolomites, with 40 per cent of more of magnesium carbonate. No definite relations seem to underlie their respective occurrence and both calcic and dolomitic marbles are found in the same belts and sometimes in close association.

The southeastern New York marbles occur in belts which follow the north-south valleys that parallel the ranges of hills to the east of the Hudson from Manhattan island north to Columbia county. On the west side of the river in Orange county are found a few smaller belts. In this region the marbles mostly belong to the dolomite class. They are interfolded with schists and quartzites, the whole series having steep dips like those of strongly compressed strata. The geologic age of the southern belts may be Precambrian, but on the north and east within the Taconic area they are perhaps Paleozoic. Individually the marbles range from very coarse to fine-grained rocks, white to grayish in color, rarely showing color pattern and are either magnesian marbles or true dolomites.

Some compact granular limestones that are capable of taking a good polish are classed as marbles in the trade. They lack the brilliancy of the crystalline varieties, but may possess an attractive color or a variety of pattern such as is lent by the presence of fossils. In some instances a subcrystalline texture has been developed as a result of solution and precipitation of the carbonates by ground

waters. There are quarries in the Chazy, Trenton and Becraft limestones that have produced stone for decorative purposes.

The marble quarries reported a more active business last year than in 1915, which was an exceptionally dull season. The value of the output reached \$268,391, of which about 50 per cent represented building marble, or in exact figures \$133,238. Monumental stone accounted for \$75,587 and other kinds for \$59,566. There were 8 quarries altogether in operation distributed among Clinton, Warren, St Lawrence, Dutchess and Westchester counties.

SANDSTONE

Among the sedimentary formations which occur in the State, sandstone probably has the largest areal distribution, while in economic importance it has normally ranked second to limestone. Nearly all the recognized stratigraphic divisions above the Archean contain sandstone in one or more horizons. The kinds chiefly quarried are the Potsdam, Hudson River, Medina, Hamilton, Chemung and Portage sandstones. A few quarries have been opened also in the Shawangunk grit, the Rensselaer grit and the Clinton and Triassic sandstones.

Of the Potsdam sandstone, which represents the Upper Cambrian in New York State, the most extensive outcrops occur along the northern and northwestern borders of the Adirondacks, in Clinton, Franklin, St Lawrence and Jefferson counties. Other exposures are found in the Lake Champlain valley and a few uneroded remnants occur in the Mohawk valley. The sandstone in many places has the character of quartzite, consisting of quartz grains cemented by a secondary deposition of quartz, and is an exceedingly hard and durable material. It is the purest of the sandstones and in certain exposures carries over 95 per cent silica. There are some beds which are adapted for glass-making or for the manufacture of metallic silicon and ferrosilicon, and in fact the latter products are now being made from this material. The principal quarries of building stone are situated near Potsdam, St Lawrence county, Redwood, Jefferson county, and Malone and Burke, Franklin county.

The Medina sandstone has been quarried extensively for building stone, paving blocks and curbstone, and there is still an important industry based on the production of those materials in Orleans and Niagara counties. It is a fine-grained sandstone of pink, white and variegated color. The pink is an excellent free-stone that has been employed in many of our cities for large structures.

The Shawangunk conglomerate is more widely known for its use in millstones than for constructional purposes. It outcrops along the Shawangunk mountain ridge in Ulster county. The quarries near Otisville have supplied considerable quantities of stone for abutments and rough masonry.

The Rensselaer grit is limited to a rather small belt in the so-called Rensselaer plateau east of the Hudson river. The stone has a close texture which may resemble that of a trap, and is used for crushed stone. The largest quarries are near Brainard Station, Rensselaer county.

The sandstones in the Hamilton, Portage and Chemung formations of the Devonian are popularly known as bluestone, a name first applied to those in Ulster county where in many places they are distinguished by a bluish gray color. They are for the most part fine-grained, evenly bedded, bluish gray, green or pinkish sandstones, that often have a well-developed "reed" or capacity for splitting along planes parallel to the bedding so as to yield smooth, thin slabs. For that reason they are extensively used for flag and curbstone, and a large industry is based on the quarrying of these materials for sale in eastern cities. Most of the flagstone is produced in the region along the Hudson and Delaware rivers, where there are convenient shipping facilities to New York, Philadelphia and other places on the Atlantic coast. The Hudson River district includes Albany, Greene and Ulster counties, but the quarries are mainly situated in the area that includes southern Greene and northern Ulster, with Saugerties and Kingston as the chief shipping points. The Delaware River district embraces Sullivan, Delaware and Broome counties; the shipping stations are along the Erie and Ontario & Western Railroads. Large quarries outside of these districts are found near Norwich, Chenango county, and Warsaw, Wyoming county, which produce building stone chiefly, for the general market. Numerous small quarries have been operated at different times in Otsego, Chemung, Tompkins, Tioga, Schuyler, Steuben, Yates, Allegany, Cattaraugus and Chautauqua counties.

The production of sandstone in 1916 showed a decline of about 20 per cent, marking a continuance of the downward trend in the business that has been noted for several years past. The combined value of the output was \$714,558, whereas in 1915 it amounted to \$890,411. The extent and rapidity of the decline in this branch of the quarry industry may be appreciated from the figures reported 10 years ago: in 1907 the total was \$1,998,417 and in earlier years

it reached over \$2,000,000. An examination of the conditions year by year shows that the industry has been depressed by the strong competition it has had to meet from other kinds of material in the building and city engineering markets. Granite and cement have been gradually superseding sandstone for street work, and the same holds true for building stone.

Of the total returned for 1916, the bluestone quarries reported an aggregate value of \$376,845, against a value of \$339,779 in the preceding year. The slight gain may doubtless be accounted for by the high prices of cement that ruled during the year. The value of the building stone included in the total was \$168,834 against \$178,577 in 1915. Curb and flagstone amounted to \$169,973, against \$155,288 in 1915. Of other kinds, there was produced crushed stone valued at \$27,767 and miscellaneous kinds valued at \$10,271. The Hudson River district accounted for an aggregate of \$98,669, mostly curb and flagstone; the Delaware River district contributed \$67,493, made up largely of curb and flagstone but with some building stone.

The sandstone other than bluestone represented a value of \$337,713 as compared with \$550,632 in 1915. Paving blocks were the largest single item, with a value of \$131,430, while crushed stone was worth \$96,788, building stone \$16,137 and other kinds \$4284. Orleans county alone contributed a product worth \$226,945, which was little more than one-half of the value reported in 1915, in actual figures \$449,620.

TRAP

Trap is not a distinct variety of rock, but the name is given collectively to the fine-grained, igneous rocks that occur in intrusive sheets and dikes. From granite it differs by its darker color, due to the absence of quartz and, the participation of the ferromagnesian minerals in large amounts. Some of the so-called "black granites," however, are really trap. The particular value of trap lies in its hardness, toughness and lack of cleavage. Its fine, compact, closely knit texture gives the stone great wearing powers, and it is eminently adapted for road metal and concrete of which heavy service is required. The principal outlet, therefore, is for crushed stone. It has been used to some extent, also, for paving blocks, but these are rather difficult to prepare, since trap very seldom shows any capacity for parting comparable to the rift and grain structures of granites. As building stone it finds very little application, probably on account of its somber color. The expense

of cutting and dressing trap is also an obstacle to its employment for building or ornamental purposes.

The largest body of trap in New York State is represented in the Palisades of the Hudson, and the continuation of the same intrusion is found southward in New Jersey and on Staten island. This occurrence, properly, is diabase, with plagioclase, feldspar and pyroxene as the main ingredients. The Palisades are the exposed edge of a great sill or sheet of the rock which came up from below and forced its way along the bedding planes of the Triassic sandstones and shales. The sheet is several hundred feet thick, in places nearly 1000 feet, but the outcrop is narrow, seldom over a mile wide and in places is limited to a single vertical escarpment. The principal quarries are near Nyack and Haverstraw at the base of the cliffs. Other quarries have been opened near Suffern, on an isolated intrusion of a similar rock, and also near Port Richmond, Staten island, at the southern end of the Palisades sill.

There are numerous occurrences of trap in the Adirondacks, where it occurs in the form of dikes that intersect the older Precambrian crystalline formations. The dikes occur literally in thousands in Essex and Clinton counties, but they seldom attain any considerable thickness, 20 to 30 feet being about the maximum. Near Greenfield, Saratoga county, and at Little Falls, Herkimer county, occur dikes of much larger size. The Greenfield dike has been worked in years past for crushed stone.

The output of trap in 1916 was valued at \$956,100, a large gain over the total of \$550,960 reported in the preceding year. The quantity of crushed stone reported was 1,280,500 tons, consisting of crushed stone for roads 561,000 tons, for railroad ballast 64,250 tons, and for concrete 655,250 tons. In 1915 the quantity was reported in cubic yards and amounted to 683,700, a yard amounting to nearly one and one-half tons.

TALC

The conditions in the talc trade showed notable improvement in 1916 and more than made up for the dulness of the preceding season. The demand in the paper trade was especially active, with the curtailment in the supply of foreign clays which used to enter the market very freely. In their place southern clays are being employed quite extensively, but not in the full proportion to the former use of foreign material. While the paper industry, especially the branches engaged in book and writing paper manufacture,

are the largest consumers of St Lawrence county talc, other important outlets are found in the manufacture of wall plasters, in the paint and rubber trade, and many other industries.

The production reached record figures, amounting to 93,236 short tons valued at \$961,510, larger by nearly 20,000 tons than the total reported in the best previous year. The contributing mining companies were the same as enumerated in the preceding year, inclusive of the International Pulp Co., the Uniform Fibrous Talc Co., and the Ontario Talc Co. in the Gouverneur district and the St Lawrence Talc Co., with a mine at Natural Bridge. The International Pulp Co. operated several mines situated in the Talcville and Sylvia Lake sections, the principal producers having been No. 2½ and No. 3 mines in the former section and the Balmat mine in the other. The Uniform Fibrous Talc Co. worked its single property on Wintergreen hill, below Talcville, where its mill is also situated. The Ontario Talc Co. lost its mill by fire and has gone out of business. Its mine near Fullerville contains a good body of fibrous talc and will doubtless be worked again, although it has been allowed to fill with water.

The St Lawrence Talc Co. produces a different grade of talc from the others, which finds special uses.

There has been no new work undertaken in the St Lawrence county talc district for several years. The industry in fact suffered for a long time from overexpansion, with mine and mill capacity that far exceeded the market outlet for the product. This condition has been gradually remedied by the shutting down of mines from time to time, and recently by the unexpected expansion of the trade which it is not yet certain will prove more than a temporary feature. There is no doubt that the profits in the business hitherto have been smaller than they should have been by reason of competition among the producers on the one hand and the payment in many instances of excessive royalties to the owners of the mineral rights covering the talc. The latter are often held apart from the land surface and the owners have been able to exact heavy royalties, amounting to as much as \$1 a ton on the output, several times over what is ordinarily considered a fair tax on other minerals of approximately the same value.

The talc business was started in St Lawrence county in the last of the seventies of the last century, and began to take on importance about 1880 since which time the output has amounted to nearly 1,800,000 tons valued at nearly \$16,000,000.

ZINC

The production of zinc ore in 1916 was all made by one mine, that of the Northern Ore Co., which began operations in the preceding year. The shipments were in the form of mill concentrates, carrying around 48 or 49 per cent zinc. They were of such size as to place the property on a very successful basis, in fact establishing it as one of the prominent zinc mines in the east. Owing to the fact that there were no other producers, the actual figures of output are withheld from publication.

The developments in the mine at Edwards have continued to be favorable and have warranted the policy of gradual expansion of operations. A vertical shaft was started to intercept the ore bodies on their extension in dip that have been worked through the Brown incline. The shaft starts in the gneiss, overlying the limestone ore formation. It is expected to continue the shaft to a depth of around 800 feet but it will be used for production before that point is reached, since the first ore body will be encountered at around 500 feet. The drift on the 400-foot level of the Brown shaft has been extended northeast to test the ground explored by the White and Williams shafts which are not used for hoisting, all the ore from that section being taken to the Brown shaft on account of its convenient situation.

There is enough ore assured on the property to sustain operations for several years to come.

Prospecting was carried on in other parts of the district but no deposit was actually developed to the productive stage. So far little more than surface testing, supplemented by diamond drilling in one or two places, has been undertaken.

No new occurrences in addition to those listed in the report for 1915 have been uncovered during the year.

In southeastern New York preparations were under way for restoring some of the old mining properties along the Shawangunk mountain ridge, which were opened 75 years ago and worked for a time for the lead content of the ore. The principal work in 1916 was in the Summitville property, which was taken over by the St Nicholas Zinc Co. The ore body consists of a brecciated zone in Shawangunk grit that has been filled by secondary quartz and the sulphides of zinc, lead, iron and copper. The principal fracturing has taken place along the bedding of the sandstone, and the vein consequently conforms with the dip and strike of the wall rock, although the boundary between ore and rock is more or less irregu-

lar. The sandstone shows effects of alteration by the mineralizing solutions, becoming charged with iron oxides and in places developing a greenish decomposition product.

The workings from the former operations consist of several openings on the outcrop some 200 feet below the ridge summit, together with an adit and level 220 feet below the line of outcrop, measured along the vein. This level is about 400 feet long north and south. The ore here dips 35° west and ranges from a few inches to 4 feet in thickness. A second adit was driven into the hill lower down at the level of the mill but did not encounter the vein.

Assays of ore samples as reported to the writer by Mr Kirby Thomas, consulting engineer for the company, showed an average of 21 per cent zinc, 12.6 per cent lead, a little copper and an ounce or two of silver. The sample represented the rich part of the vein of an average thickness of 18 inches.

The plans of the company are to mine the ore already in sight and simultaneously to carry on exploration for additional supplies. The milling operations are intended to effect a saving of both lead and zinc. The site of the new mill is close to the tracks of the Ontario & Western Railroad, near the base of the ridge. A 1600-foot aerial tramway will lower the ore by its own gravity from the working adit to the mill. J. MacDonald Mitchell is the engineer in charge.

At Wurtsboro, to the south of Summitville, is a similar occurrence of lead and zinc sulphides. It is referred to in the reports of the First Geological Survey as the Shawangunk mine, and Mather states that three solid masses of galena weighing 800, 1000 and 1400 pounds were taken from the vein at the time of his visit to the property about 1838. The vein apparently parallels the bedding planes of the grit and ranges up to 5 feet wide.

The Ellenville mine is another of the occurrences, similar in its metal contents to the two just described but differing in the fact that the vein occupies a cross-fracture in the sandstone rather than conformable with the bedding. It has been worked at different times since its first opening, which is stated by Mather to have been 23 years before his investigation, or before 1820. It is famous for specimen ores, which exhibit crystallized quartz intergrown with chalcopyrite, galena and sphalerite, also often in good crystals. A mill equipped with crushing and separating machinery of modern type remains on the property from the last period of operations in the years 1903-4.

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NOVEMBER 1, 1916

The University of the State of New York
New York State Museum
JOHN M. CLARKE, Director

GEOLOGY OF THE VICINITY OF OGDENSBURG

(Brier Hill, Ogdensburg and Red Mills Quadrangles)

BY H. P. CUSHING

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The University of the State of New York

Science Department, July 6, 1916

Dr John H. Finley

President of the University

SIR: I beg to communicate herewith a manuscript entitled "The Geology of the Vicinity of Ogdensburg" with appropriate maps. This manuscript has been prepared by Prof. H. P. Cushing, temporary member of this staff, and I recommend its publication as a bulletin of the State Museum.

Very respectfully

JOHN M. CLARKE

Director

THE UNIVERSITY OF THE STATE OF NEW YORK

OFFICE OF THE PRESIDENT

Approved for publication this 11th day of July 1916

A handwritten signature in dark ink, appearing to read "John H. Finley". The signature is written in a cursive style with a large initial "J" and a long horizontal stroke extending to the right.

President of the University

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GEOLOGY OF THE VICINITY OF OGDENSBURG

BY H. P. CUSHING

INTRODUCTION

The chief purpose in mind in undertaking the areal mapping of the district here reported upon was to make a careful study of the Beekmantown formation in the district of the upper St Lawrence, in order to see how fully it was represented and how it compared with the formation in the Champlain valley. Between Ogdensburg and Morristown excellent sections of the formation are shown so that, in so far as the lower portion of the formation is concerned, the work was very successful. Down the river from Ogdensburg, however, the glacial drift is very widespread and heavy, and rock exposures are infrequent and scant; so much so that it is highly questionable whether a satisfactory idea of the higher beds of the formation can be obtained.

Prof. G. H. Chadwick was engaged in mapping the Paleozoic rocks of the Canton quadrangle, at the same time that our work was in progress, giving opportunity for us to keep in touch with each other, and to make a definite comparison of results. This has proved of especial help since, owing to heavy drift, the rocks east of Ogdensburg on the Ogdensburg quadrangle are almost completely covered up, and a formation wedges in there and appears strongly on the Canton quadrangle, where Professor Chadwick recognized it, which would probably have entirely escaped our notice on Ogdensburg.

In 1913 both Dr E. O. Ulrich and Dr R. Ruedemann spent two or three days with me at Ogdensburg, looking over the section with me and giving indispensable assistance. They have also spent much time in determination of the fossils collected, hence a large part of such merit as the report may have is owing to their aid.

LOCATION AND CHARACTER

The district here reported upon comprises the Brier Hill, Ogdensburg and Red Mills quadrangles of the topographic map sheets. The southwestern margin of the Brier Hill sheet overlaps by a trifle the northeastern corner of the Alexandria Bay sheet, so that the mapping is a continuation, down the river, of the work done in the Thousand Islands region.¹ In the latter territory the Paleozoic rocks found are chiefly those to the south of the Frontenac axis, as the belt of crystalline rocks which comes down to and crosses the river at the Thousand Islands is called. In the Ogdensburg district the Paleozoics are those to the north of this axis, and the contrast between the two will be subsequently shown.

The mapped area extends from longitude $75^{\circ} 15'$ to $75^{\circ} 45'$ W. and from latitude $44^{\circ} 30'$ to the St Lawrence river. It is of triangular shape, since the river flows northeast. At the west edge of the Brier Hill sheet the river crosses the parallel of $44^{\circ} 30'$; at the east edge of the Red Mills sheet the south bank of the river is about at latitude $44^{\circ} 52'$. The area included is about 320 square miles.

The district lies entirely in the topographic province of the St Lawrence plain, though its southern margin might be said to belong to the northwest edge of the Adirondack highland. On the northwest there is not the sharp junction between these two topographic provinces that there is farther east, but a very gradual drop from the one to the other.

The district lies also on the boundary between two geologic provinces, which correspond in a general way with the topographic. The crystalline rocks of the Adirondack highland descend to low levels in this vicinity, and cross into Canada at the Thousand Islands in a narrow belt, furnishing an isthmianlike connection between the great area of these rocks in the Adirondacks, and the vastly greater area in Canada. Below the Thousand Islands the river flows through a country of low altitude whose rocks are flat-lying formations of early Paleozoic age, and crystalline rocks do not reappear along the river west of Quebec. The general breadth of this Paleozoic plain of the St Lawrence valley, which separates the Adirondack highland from the Canadian highland, is from 60 to 70 miles, but three-fourths of this breadth, and of the plain, lies on the Canadian side of the river.

¹ N. Y. State Mus. Bul. 145.

GENERAL TOPOGRAPHY

The mean level of Lake Ontario and of the St Lawrence through the Thousand Islands is 246 feet above tide. At Ogdensburg it is only 2 feet lower than this, but on the 12 miles of river across the Red Mills quadrangle there is a rapid drop at the Galop rapids, from 244 feet above the rapids to 228 feet at Rockaway point, 16 feet in 8 miles. The levels of the river are the lowest levels in the area mapped.

The highest land on the Ogdensburg quadrangle is around Dekalb Junction in the extreme southeast corner where an elevation of 470 feet is reached. This gives for the quadrangle an extreme of relief of only 225 feet, a very small amount; and the bulk of the quadrangle lies between 300 and 400 feet altitude. On the Brier Hill quadrangle it is even less, since 400 feet is exceeded in only two places, and 440 feet is the highest point, only 200 feet above the river.

The minor relief on the Brier Hill sheet is considerable, much of the surface consisting of slopes; there are many rock exposures, and hence very little guess work is necessary in working out the geology. But the entire northern half of the Ogdensburg quadrangle consists of a plain with little relief, and so covered with glacial drift that rock exposures are very infrequent, and the mapping of formation boundaries is a very uncertain matter.

Drainage. The mapped area drains entirely into the St Lawrence, the chief stream being the Oswegatchie river, which is one of the five good-sized streams which drain out from the Adirondacks to the northwest, the others being the Black, Grass, Raquette and St Regis. Five miles south of Ogdensburg, Black lake, which is nothing but an expansion of the waters of the Indian river into a lake, empties into the Oswegatchie. The Indian river is a considerable stream, but not comparable to the others in size.

The general slope of the district is to the northwest, toward the St Lawrence. This is, however, at right angles to the geologic grain of the country which trends northeast. Most of the preglacial valleys of the district have this northeast trend. Black lake lies in a preglacial valley; and the adjacent valleys of Fish creek and Beaver creek have the same trend and are small preglacial valleys. South of Rensselaer Falls the Oswegatschie is now occupying the preglacial valley of a small stream; but below that point its course seems entirely postglacial, and it has no valley worthy of the name,

but flows in a shallow trench cut chiefly in glacial deposits, with rock seldom showing, and with rapids in the stream wherever it is on bedrock.

The St Lawrence, in its course across the Brier Hill sheet, seems to be occupying an old valley; at least there is a well-defined valley rock wall on the New York side. But below Ogdensburg it has the same characteristics as the lower Oswegatchie, no well-defined valley, low banks of drift with no rock showing, and rapids in the river whenever it discovers rock ledges in its bed, as at the Galop rapids.

GLACIAL DEPOSITS

All the surface of the district is below the levels of the bodies of standing water which existed in the region during the closing stages of the Glacial Period, and practically all of it is beneath the level of the marine waters which invaded the St Lawrence valley when the final melting away of the ice sheet cleared a way for their passage. On the Brier Hill sheet the wave action of these water bodies swept away most of the glacial deposits from the higher rock surfaces and into the old depressions, which are deeply filled with them. The low grounds which comprise all the north half of the Ogdensburg are so drift-covered that rock outcrops are exceedingly scarce, but the drift has comparatively little surface relief, was probably all laid down under standing water, and has since all been wave-washed.

A well-defined morainic belt extends across the Ogdensburg and Red Mills sheets, parallel to the river. It has a breadth of several miles and seems to be broadening eastward, with the widening of the Paleozoic plain. But the moraine has a very subdued relief, the knobs being low and of gentle slope, with seldom a relief of as much as 40 feet above the low grounds. Nor does the material appear to be particularly thick; we doubt if it would average 40 feet thick.

This moraine does not extend far west on to the Brier Hill sheet, on which rock exposures abound and drift is heavy only in the pre-glacial valleys. On the south half of the Ogdensburg sheet, also, there is no widely spread drift cover. The rock relief is greater there than to the north and the drift is solely in the depressions. The depressions are often marshy.

The morainic belt is, to a considerable extent, drowned beneath the clay plain formed by deposit in the standing waters, so that the

general surface is a clay flat, above which the higher knobs of the moraine project.

The only considerable drift hill in the whole mapped district is the rather boldly projecting ridge known as Mount Lona, about 2 miles south of Heuvelton, midway of the Ogdensburg sheet. Its north front is at the river edge, at the sides it rises rather abruptly from low, flat country, it trends southwest, parallel with the general direction of ice motion, has a length of about a mile and one-half, and a breadth of one-half of a mile. Its summit has an elevation of 466 feet, the highest point on the map with the exception of one or two of the granite knobs near Dekalb Junction, which are a few feet higher. It towers 160 feet above the country on the north and east, and 100 feet above that on the southwest.

The ridge is entirely composed of bouldery drift, probably morainic. It stands on a sandstone plain, with rock near the surface, and occasionally outcropping around the margins of the knob. A low moraine stretches from it toward the southwest, but a moraine of no particular bulk or prominence. The hill somewhat suggests a drumlin, though somewhat more abrupt, more prominent and more elongated than the usual drumlin. The lack of other hills of the same type in the district tends to throw doubt on such a classification also. We were unable to devote any particular attention to the drift deposits of the region, and simply chronicle this hill as an interesting point for study. Because of its prominence it was thought that perhaps shore line features would be shown upon it, but we could detect none, and apparently the marine waters must have overtopped it somewhat.

A much smaller and less conspicuous hill of similar type is that at Lost village, 5 miles south of Ogdensburg, on the west side of the Oswegatchie at the point where Black lake outlet empties into it; this is also a purely morainic hill, resting on bedrock, and with no particular connection with a morainic belt.

Though the general surface of the Ogdensburg quadrangle consists of a clay plain, above which low, morainic summits rise, locally considerable sand rests upon the surface. Much of the sand is in the lee of the moraine knobs, in the fashion of sand spits, similar to the many occurrences of the same sort on the Theresa and Alexandria Bay quadrangles. But there is also much sand as knolls mingled with the moraine knobs, which seem to be of the kame type, and the chief moraine is probably a kame moraine, its features masked because of its subaqueous formation.

GENERAL GEOLOGY

The rocks of these three quadrangles consist of (*a*) crystalline rocks of Precambrian age and (*b*) early Paleozoic rocks of the St Lawrence trough which lie upon the Precambrian rocks. The Precambrian rocks are the characteristic rocks of the Adirondack region, are as old as any rocks of which we have knowledge, consist in part of sediments and in part of igneous rocks, and have but small extent on the sheets here reported upon, occupying about one-fourth of the area of the Ogdensburg sheet, and occurring in the southeast corner of the Brier Hill sheet. On the Hammond and Gouverneur sheets, next south, however, they occupy most of the territory. The overlying Paleozoic rocks extend solidly along the St Lawrence in a strip a few miles in breadth, and the lowermost member, the Potsdam sandstone, is also found in outlying patches within the area of the crystalline rocks. The crystalline rocks are much older than the Paleozoics, venerable as the latter are, and in the time interval between the two sets of rocks the region existed as a land area for a very long period, during which time much rock material was slowly worn away from its surface. It is upon this worn and somewhat irregular surface of the crystalline rocks that the Paleozoic rocks rest. They have remained comparatively undisturbed since their deposition, and still lie nearly flat and unbroken, as laid down, presenting the strongest kind of a contrast to the greatly deformed Precambrian rocks.

DESCRIPTIVE GEOLOGY

PRECAMBRIAN ROCKS

The Precambrian rocks of northern New York comprise an old series of sedimentary rocks, known as the Grenville series, which are the oldest known rocks of the region, and various masses of igneous rocks, all of which cut the Grenville rocks intrusively and are therefore younger than they are. The older set of these intrusives consists chiefly of granite, while a younger set consists of granites, syenites, gabbros and anorthosites. Where both sets are present and in contact with one another, as is the case in the Thousand Islands region, it is possible to class them in their appropriate groups, on the evidence of their structural relations to one another. But where such contacts can not be found, such classification is a difficult and hazardous matter. To the older set of

these intrusives the name of Laurentian is applied; for the younger set certain of the Canadian geologists have recently suggested the name "Algoman." It is not certain to which of these groups the granites in Dekalb and in Macomb belong. But both granites and syenites are well represented in the small Precambrian area which the maps contain.

Much later in Precambrian time came renewed igneous intrusion, and black, heavy lavas, so-called trap rocks, rose toward the surface. Such traps are well represented in the Thousand Islands, but in the district here mapped but two small dikes of this rock have been seen.

The Grenville rocks in considerable diversity are found in the southern part of the Ogdensburg quadrangle. They are cut by granitic, syenitic and gabbroic eruptives, and by trap dikes.

The Precambrian rocks exposed within the mapped area cover such a trifling amount of territory, being the mere northern fringe of the great and well-exposed areas of these rocks on the Gouverneur and Hammond sheets next south, that it seems unwise to attempt any elaborate investigation of them until these sheets have also been studied. Since it is our present plan to commence study of the Gouverneur area, the detailed report upon the Ogdensburg Precambrian will be left until that work is completed.

Grenville series. The Grenville series in the Adirondacks exhibits an enormous but unknown thickness of limestones, quartzites and various sorts of schists and gneisses. These are water deposited rocks and were unquestionably deposited in great thickness over the entire region. Not long after their deposit, however, they were invaded from beneath by huge masses of molten granite; and at a subsequent time by even greater masses of a variety of igneous rocks. This action broke up the old series into a group of disconnected blocks and patches, separated by masses of the intrusives, so heated and compressed the sediments as to cause complete recrystallization of their constituent parts, and vastly changed their appearance. The pure limestones were changed into white marbles, with scales of yellow mica and of graphite always present. The less pure limestones are full of other silicates in addition, chiefly pyroxenes and scapolite. The sandstones were changed into quartzites and quartz schists. The shales were altered to schists of various sorts. Contact rocks were produced at the contacts of many of the igneous rocks, and these also have been recrystallized to schists and gneisses. Often there is great difficulty

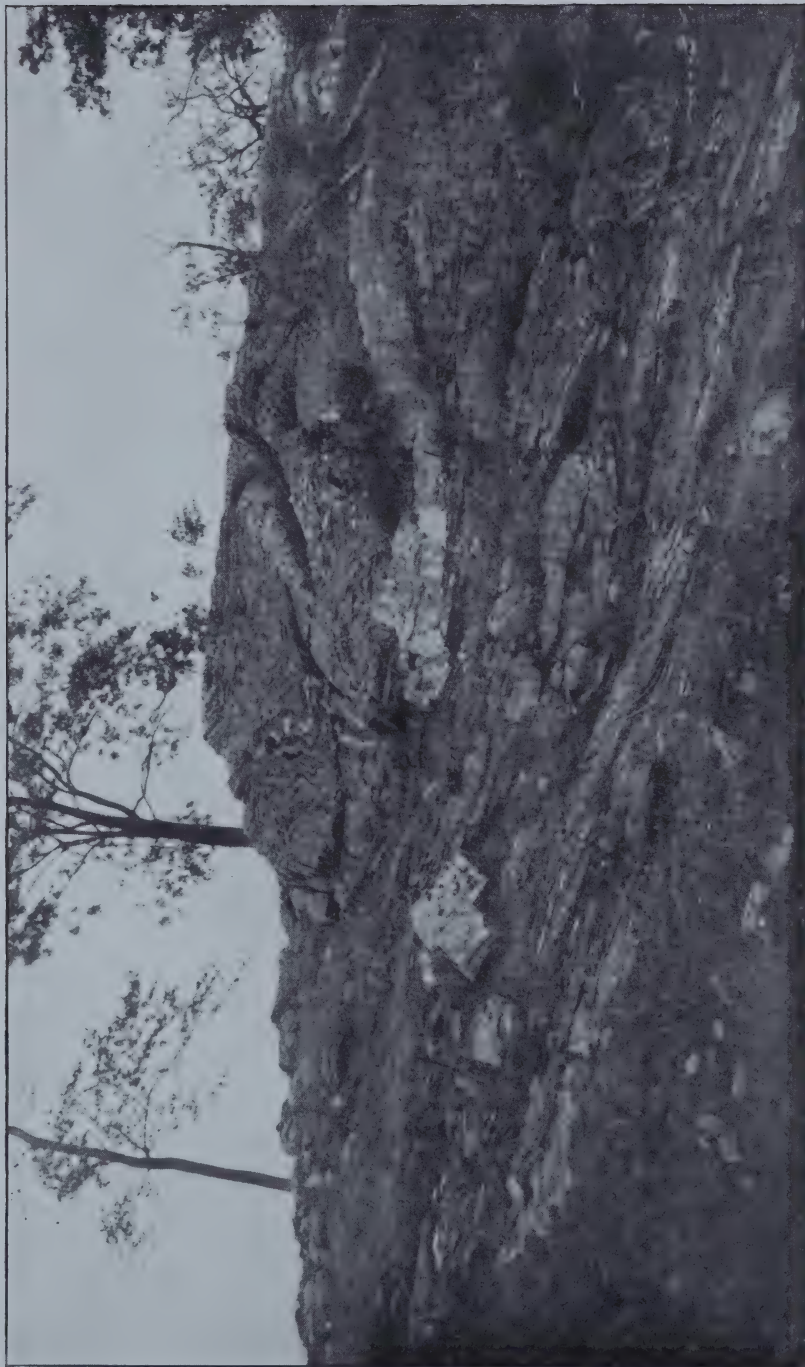
in determining just what the nature of the original rock may have been.

Limestone. An unusually large proportion of the exposed Grenville on the Ogdensburg sheet consists of limestone. A great belt of limestone comes on to the sheet at its southwest corner and the rock is magnificently exposed along the east side of Mud lake, and runs northeast from there in a prominent belt more than a mile in width, its western portion overlapped and covered by Potsdam sandstone. The Grenville limestone is a weak rock in its resistance to erosion, tends to form low grounds and to be heavily covered with soil, so that outcrops are scarcer than in most of the Grenville rock belts, that is, belts of other rock. To the east of this belt are two narrower belts, one east and one west of the Oswegatchie, but in these the limestone is less pure and alternates with thin bands of quartzite and of schists. The areal distribution of the limestone suggests a series of folds pitching to the northeast.

Frequent knobs of granite are found cutting through the limestone, especially in the belt which borders the Oswegatchie on the east. These are more resistant to erosion than the limestone and form the more prominent outcrops in the limestone belts; in fact the great majority of the limestone outcrops are found on their borders. These granite knobs in every case consist of *white* granite, though the granite masses elsewhere are red. It seems to be the same sort of bleaching of the granite at limestone contacts as has been described in the Thousand Island region.

Quartzite. There is no considerable belt of quartzite in the Grenville series of the Ogdensburg quadrangle, though there are narrow belts of it involved with impure limestone in alternating layers, too narrow to map on this scale as separate from the limestone. There is still more of it in narrow bands interbedded with amphibolite and rusty gneiss, all too narrow to map separately and hence mapped simply as Grenville schist. The quartzite is thin bedded, is really quartz schist, and exhibits everywhere minute folding and puckering, showing these features much better than any other rock in the district (plates 1 and 2).

Schists. The larger portion of the area which is mapped as Grenville schists is occupied by the dark-colored rock conveniently known as amphibolite, and made up chiefly of feldspar and hornblende, often with some pyroxene as well and commonly with black mica in addition. When the mica becomes prominent the rock cleaves readily and becomes rather weak. From these thinly



H. P. Cushing, photo, 1913

Closely folded Grenville quartzite, two miles south of Kindreds Corners



II. P. Cushing, photo, 1913
Closely folded Grenville quartzite, two miles south of Kindrews Corners

foliated mica schists there are all gradations into a solid, massive black rock, fairly coarse grained, and with a poor foliation, which is a rather typical amphibolite.

The amphibolites found in the Adirondack Precambrian look much alike, but have originated in at least three quite different ways and from rocks which were originally unlike. In part they represent metamorphosed calcareous shales, which occur in beds within the Grenville series and are an integral part of that series. They are also produced from somewhat impure limestones as a result of the contact action of granitic intrusion upon these limestones. Such amphibolites are found only at such contacts, and should show a gradation back into limestone as we recede from the contact. In still other parts the amphibolites are produced from original basic igneous rocks, gabbros, due to recrystallization under the conditions of heat and pressure which have so profoundly changed all these old rocks from their original condition.

There are probably amphibolites of all three origins within the Ogdensburg quadrangle, but much uncertainty prevails in regard to most of the occurrences. The belt of schists at the eastern margin of the sheet, between the granite and the Potsdam, consists of a jumble of thin beds of many sorts of rock, much folded and contorted and following one another in rapid succession. Thin limestones and quartzites are interbedded with impure limestones, garnet schists, amphibolites and other schists in such wise that they could be separately mapped only on a very large scale map with the aid of multitudinous exposures. The amphibolites here, however, seem certainly to be metamorphosed shales.

Midway of the southern margin of the Ogdensburg sheet is a broad belt of Grenville amphibolite much involved with porphyritic granite. The granite occurs in long, narrow tongues in the amphibolite, but these hold many inclusions of amphibolite. The amphibolites are cut by a multitude of narrow dikes from the granite, and in places are much granulated and soaked by the granite, with the production of mixed rocks. The granite also carries much black mica, and is thoroughly foliated, so that, in the places where the porphyritic crystals of feldspar fail, it looks not unlike some phases of the amphibolite. The main granite tongues can be mapped, and the chief amphibolite masses are readily differentiated from them, but there remains much mixed material, here mapped with the amphibolites, which forms a very puzzling combination. The amphibolite itself also varies greatly. The central part of the mass, that

between the two inner granite tongues, is a solid, massive rock which we can interpret only as an intrusion of altered gabbro. It shows two phases, a fine-grained, pepper and salt combination of feldspar and hornblende in about equal quantities; and a coarser, more blotchy looking rock, of similar composition. This central area has been definitely mapped as gabbro, though its boundaries are very indeterminate. The marginal portions of the mass are more micaceous, much better foliated and less massive, much cut up by granite and quartz veins and dikes, and locally soaked by the granite. Here much of the rock is so exactly like the amphibolites interbedded in the Grenville and considered to be metamorphosed shales, that we are in doubt how to class them. They have the gabbro on one side of them, and Grenville limestones on the other. All are cut by, and therefore older than, the granite.

All the granites of the region contain frequent inclusions of the Grenville rocks, and in almost every case these inclusions consist of amphibolite, and inclusions of limestone are never found. Beyond doubt some of these amphibolite inclusions represent altered limestone fragments; but with this exception no amphibolite was seen within the mapped area which definitely suggested such an origin.

In the variety of other schists shown in the region, mention may be made of the garnetiferous schist, for the reason that Doctor Martin has found this rock in considerable quantity on the Canton sheet, next east, and has separately mapped the belts of it there found. But two exposures of this rock have been found on Ogdensburg, one near the east margin, which is in direct prolongation of the belt on the Canton sheet, and the other in a disconnected patch near the south margin. The rock is a heavy, solid one, chiefly composed of feldspar of greenish-gray color, some quartz, much graphite in small flakes, a small quantity of black minerals, and very numerous purplish-pink garnets, averaging one-quarter of an inch in diameter.

Rusty gneiss. A very characteristic Grenville rock in all districts where they are exposed is a peculiar, weak gneiss, which weathers rapidly to a rusty-looking rock of a peculiar yellowish shade. It is usually a highly quartzose rock, holds much pyrite, whose decomposition is chiefly responsible for the peculiar appearance of the weathered rock, contains considerable graphite, as do many of the Grenville schists, and in addition certain rarer minerals, such as sillimanite. Thin bands of this gneiss are found in many

places associated with the limestones, on the Ogdensburg quadrangle, but the bands are quite too thin to map separately on this scale.

Associated with the limestones, especially as marginal phases, are dark-colored, heavy gneisses, composed largely of pyroxene, usually with much graphite also, which apparently represent rather impure limestones. These rocks, when heavily metamorphosed, lose their carbon dioxide to a large extent, and the lime combines instead with the silica present to form various lime silicates, mostly pyroxene.

IGNEOUS ROCKS

Three different varieties of igneous rocks have been mapped on the quadrangle, namely, granite, syenite and diabase. The rock mapped as syenite is really a granite, but because it differs markedly from the general granite of the region and is precisely like rock which elsewhere occurs as a marginal phase of the general syenite of the region, it is so mapped here. It occurs in long, narrow tongues which may be dike-like projections from a larger syenite body to the south on the Gouverneur sheet which is not yet mapped; or there may possibly be such a body to the north, under the Paleozoic rock cover.

A fourth variety of igneous rock should be added, namely, the solid variety of the amphibolite, already described, which is regarded as probably a metamorphosed gabbro.

Granite. Two considerable areas of granite-gneiss are exposed within the mapped district, the one in Dekalb, in the southeast corner of the Ogdensburg sheet, and the other in Macomb, in the corresponding corner of the Brier Hill sheet. A third small area is shown in Hammond, on the south margin of the Brier Hill sheet, and this is of interest as being the extreme northeast prolongation of the granite mass described as the Alexandria batholith, in the description of the geology of the Alexandria quadrangle in the Thousand Islands report.¹ From Chippewa bay this granite extends to the northeast, up the valley of Chippewa creek, flanked by Potsdam sandstone on both sides, across the northwest corner of the Hammond sheet to the Brier Hill sheet, before the adjacent Potsdam closes around it from the sides and hides its further extent. It shows on Brier Hill in but a single outcrop, but the particular interest which it has for us here is that it is a part of

¹ N. Y. State Mus. Bul. 145, p. 36-38.

the granite mass whose relations to other rocks on the Alexandria sheet seemed to indicate a Laurentian age for it. Its termination here is due to its disappearance under the Paleozoics, which have bordered its sides all the way from Chippewa bay, and which here meet over it. Its further extent to the northeast is purely problematical. It is, however, quite possible that the granite mass in Macomb, east of Black lake, is a part of the same bathylith. The Macomb granite runs out to the northeast in the same manner, namely, by having the bordering Potsdam close around and cover its prolongation. It is, however, very like the rock of the main Alexandria bathylith in character; we regard it as quite probably a part of it, and are disposed to class it as of Laurentian age, along with the Alexandria rock. Even without including it, the Alexandria granite extends for 25 miles in a northeast-southwest direction, to which must be added at each end an unknown amount under the Paleozoic cover which hides its continuation. This continued extent enables us to state that, on the Brier Hill sheet, a granite is present whose proved relations to other rocks strongly suggest its Laurentian age. Evidence of similar sort on the Ogdensburg sheet itself regarding the age of the granites there present, is lacking.

The Macomb granite, which we regard as very probably a part of the Alexandria bathylith, is in large part a fine-grained, red orthogneiss, composed chiefly of feldspar and quartz, but with a variable amount of black mica. Exposures are very frequent in the entire rugged district which it occupies. Coarse phases appear, especially at the margins, and there are frequent pegmatite and quartz veins. In the vicinity of limestone its color is bleached from red to white as described for the granites on the Alexandria sheet, and the granite knobs and dikes found cutting the limestone are all of white color. Inclusions are frequent, especially at the east and south, on approach to the bordering Grenville belts there, and, as usual, the inclusions are always of amphibolite, no matter what the nature of the bordering Grenville rock is. In this particular area, however, most of the inclusions are sharply bounded and show little sign of becoming soaked by the granite and converted into mixed rocks, as so many of the inclusions in the granites of the Alexandria Bay region do. This we take to indicate that we are here comparatively near the margin of the bathylith, and that the inclusions had been incorporated in the igneous mass in its late stage, when its fluidity was much diminished.

A narrow belt of Grenville gneiss margins the Macomb bathylith on the south and just beyond appears the northern edge of a mass of granite, which runs widely to the south on the Gouverneur sheet and which must be studied there. It is a coarser granite than the other, holds but few inclusions, and quite probably belongs to the later intrusives which we have mapped as syenite. Its precise relations must be determined by work on the Gouverneur area.

The Dekalb granite, which occupies the southeast portion of the Ogdensburg sheet, extends to the northeast onto the Canton quadrangle, where it has been mapped and studied by Martin, and also runs southwest for an unknown distance on Gouverneur. Its full breadth of about 4 miles is shown, as Grenville rocks adjoin it to the southeast just at the sheet corner.

In so far as most of the granite is concerned it is a fine-grained, red orthogneiss, quite like that at Macomb and Alexandria, chiefly a feldspar-quartz rock, with very little mica, and with inclusions of amphibolite solely, so that we should have little hesitation in correlating it also with the Laurentian, except for two things. At the western edge it becomes fairly coarse grained and, though quite gneissoid, is a quite different looking rock from the ordinary orthogneiss. At the extreme southeast outcrop on the sheet also the rock is of different character, much more micaceous than normal and resembling a mashed porphyry; in other words, bearing some resemblance to the porphyritic granites here mapped as syenite and regarded as belonging unquestionably to the later group of intrusions. One of the peculiar things about the Precambrian geology of the Ogdensburg sheet is the manner in which these long tongues of porphyritic granite appear cutting the Grenville rocks, but, so far as observed, never invading the adjacent granite-gneiss bodies. It is one of the problems on which we hope to get some light from the study of the wider exposures on the Gouverneur sheet to the south. We are in doubt as to the age of this particular granite, as to whether it should be classed with the earlier or the later group of intrusions.

The bulk of the Dekalb granite consists of finely granular orthogneiss, composed almost wholly of quartz and feldspar, and very similar to the Macomb and Alexandria rocks. Along its western margin, where it is coarse, it directly adjoins a belt of solid Grenville limestone, yet it remains of red color and shows no indication of the bleaching to white which the general Laurentian granites show in like situation. Nor does it show any bleaching near the

long limestone tongue which lies within the granite. The coarser phase of the rock is that portion which lies between these two limestone belts, and it may be a wholly different mass from the orthogneiss which lies east of it. In our experience with the two granites of the region, the older or Laurentian is the one which loses its red color at limestone contacts, and we have not yet met with the younger one affected in the same way. Nor, in our laboratory experiments on the question, did we succeed in bleaching it.¹ We are here simply trying to marshal the arguments for and against an age classification of this granite, and, as stated, we are in doubt. If it consists of two separate granites we should have no hesitation in correlating the western portion with the later, and the eastern portion with the earlier granite. But we have little direct evidence of an age difference between the two masses.

In the eastern portion of the mass we came upon evidence of bleaching of granite adjoining amphibolite inclusions, evidence chiefly obtained from a quarry opened near Dekalb Junction to obtain material for use on the state road under construction. It may be remarked that such granite gneiss makes about the poorest possible rock for road making, being exceeded in badness among the local rocks only by the Potsdam sandstone. In this quarry the granite was bleached for a few inches around many of the amphibolite inclusions. This is not a common feature of granite-amphibolite contacts and suggests that these particular inclusions are altered limestones.

Syenite. The rock mapped as syenite and regarded as a member of the later group of intrusives is, so far as its occurrence within the Ogdensburg quadrangle is concerned, not a syenite at all but a granite, and its classification is based solely on its lithologic character, as compared with rocks elsewhere in the Adirondacks. It is a porphyritic granite of a peculiar and definite type, a rock which is of fairly common occurrence in the Adirondack region and which, in our experience, occurs only as a marginal, granitic phase of the syenite bodies of the region. It is because of this that it is mapped as syenite here, and separated from the other granites, and because of this that it is regarded as belonging to the later set of intrusives. In the region here the two sets are not in contact and there is no direct evidence of their relationship to each other.

These peculiar granites are always porphyritic and often coarsely

¹ N. Y. State Mus. Bul. 145, p. 177-80.

so, feldspar crystals of an inch or more in length being not uncommon. They are always prominently gneissoid, with a conspicuous development of black mica, the feldspar crystals are strung out parallel to the foliation, and are themselves often granulated or mashed, sometimes completely, sometimes only partially. The mashed feldspars are always red, while the unmashed are lighter colored, usually gray. The rock is therefore usually a mottled looking, red and black rock, the drawnout, mashed feldspars furnishing the red constituent, and the intervening, fine-grained, micaceous portions the black. The rock is not so siliceous as the usual granite of the region, usually running about 68 per cent of silica as against some 72 per cent for the other. There is considerable quartz in the rock, but probably the quartz and much of the mica develop from recrystallization of original feldspar during metamorphism.

As they occur on the Ogdensburg sheet, the distribution of these syenite masses is peculiar. They occur as a series of disconnected, tonguelike masses, drawn out parallel to the general trend of the neighboring Grenville rocks through which they cut. Eight such separate tongues are mapped within a comparatively small area on the southern part of the Ogdensburg sheet, and there are others to the southwest on the Gouverneur and Hammond sheets. They have not been traced to any connection with a mass of ordinary syenite. Such a mass may be found on these sheets when they are mapped, from which these tongues may be dikelike offshoots. But they do not produce the impression of dikes, nor are their contacts with the Grenville of the type which would normally come with dikes. These contacts are not sharp, but exceedingly blurred. The adjacent Grenville rocks are cut by a multitude of narrow dikes running out from these tongues, so that there is a considerable intermediate zone of mixed rock around each one of them. The relations suggest the influence of a large mass of hot molten rock, much larger than indicated by the present surface exposures. It is therefore quite possible that these tongues are mere upshoots from a large mass of syenite beneath, hidden from view by the Grenville cover, but not far beneath the present surface. This suggestion is, of course, speculative, but would explain the present surface relations, and is opposed by no facts known to us.

Diabase. Only one trap dike has been seen within the mapped limits. This is found in Dekalb, about 2 miles south of Kindrews Corners and just west of the Oswegatchie. It is a large dike, 45

feet wide where measured, bears N. 25° E. and seems quite vertical. No very fresh material could be obtained from it and the alteration which it has undergone has changed its original black color to a dark green. Like all the wide dikes it is of sufficiently coarse grain so that the different minerals may be made out by the eye. Very fresh, glittering, lath-shaped feldspar crystals are abundant, along with much coarser feldspar which is somewhat altered and dull. No olivine can be seen, and the rock is the ordinary feldspar-augite-magnetite mixture usual in these dikes.

The dike does not trend with the rock strike of the adjacent rocks which, at the locality, is north-south. Where seen it cuts across Grenville quartzite and amphibolite and adjacent syenite.

Structures of the Precambrian Rocks

The Precambrian rocks are exposed over such a comparatively small area that study of the structures shown leads to little that is of value and nothing that is new. Their most prominent structure is foliation. The Grenville rocks are believed to be greatly folded, but little that is definite concerning the folds can be made out from the study of such a small area.

Foliation. In the Ogdensburg region the foliation cleavage which has been developed in the Grenville rocks under metamorphism is closely parallel to the bedding, and this seems to be the case throughout the Adirondack region. Strike and dip readings on the one therefore correspond to those on the other.

The general strike of the Grenville rocks of the district is north-east-southwest. But there is much local variation from this general direction. Our readings vary from N. 10° W. to N. 85° E. Often there is rapid local variation due to folding. Along the Oswegatchie nearly north-south strikes prevail; along the east margin of the Ogdensburg sheet the strike has swerved to the northeast and beyond, and so continues on to the Canton sheet; passing westward toward and on to the Brier Hill sheet, it has gone back to the northeast. This is also its general direction in the Thousand Islands region.

The general dip is to the northwest. It is usually steep, in excess of 45° , and locally becomes vertical. Locally also it varies, passing from northwest to southeast and back again within narrow limits, indicative of local plications. The only part of the area within which southeast strikes prevail is a narrow belt on the east side of the Oswegatchie, on the south margin of the Ogdensburg sheet.

Folds. If the Grenville rocks are folded, as they assuredly are, the folding must be of the close and overturned type in order to give rise to dips so prevailingly in one direction as they in general present in northern New York. The general northwesterly dip in this district, for example, seems to us to imply that the folds are all tipped over toward the southeast, so that the dips on both limbs incline to the northwest. The distribution of the limestone on the Ogdensburg quadrangle suggests that we are dealing with one great bed of limestone, pinched into a syncline, the two sides diverging southward, meeting and joining on the north, and hence indicating that the syncline pitches to the southwest, and that the inclosed amphibolite is younger. But the mapped area is too small, the adjacent area too little known, and the structure too complicated, to warrant anything more than this suggestion, to be confirmed or disproved by later work.

The very contorted and complex crumpling and plication which certain beds of the Grenville show, is of itself indication of larger scale folding. Of all the rocks of the group the thin-bedded quartz schists best exhibit such plications. Plates 1 and 2 are from photographs of such quartzite, 2 miles south of Kindrews Corners.

Close folding is also shown in the combination of thin-bedded impure limestones, pyroxene schists and garnet gneisses which occur north of the Dekalb granite on the east margin of the Ogdensburg sheet.

PALEOZOIC ROCKS

General statement. The Paleozoic formations found within the mapped area are the Potsdam and Theresa formations, of upper Cambrian age, and the Tribes Hill and Ogdensburg formations, of Lower Ordovician (Beekmantown) age. They rest with marked discordance on the irregular surface of the Precambrian rocks. There is some evidence that still another formation will have to be separated from the upper part of the Theresa, including what we have mapped as the Heuvelton sandstone lentil of the Theresa formation, the beds between this sandstone and the base of the Tribes Hill, and the 30 feet (more or less) of sandy beds just under this sandstone. But the evidence is not yet decisive, and lithologically the beds are much like those of the Theresa, with which they form a convenient lithologic unit.

It is quite possible that beds of later Ordovician age, Chazy, Black River, even Trenton and Utica beds, may have once been deposited in the district, but if so, erosion has left no trace of them.

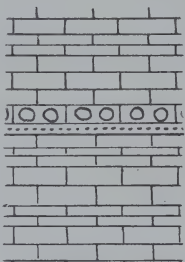
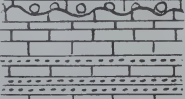
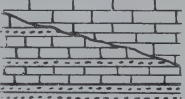
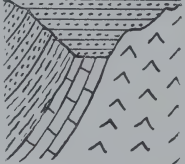
SYSTEM	FORMATION	SYMBOL	SECTION	THICKNESS	CHARACTER OF FORMATION
Ordovician (Beekmantown)	Ogdensburg formation	Oo		120' +	Alternating beds of massive, blue-gray, granular dolomite, and thin-bedded, iron-gray, fine-grained dolomite: with an occasional bed of gray, calcareous sandstone
	Tribes Hill formation	Ot		0'-40'	Thin-bedded, blue, sandy limestones above and below, with an intermediate, more sandy member
Cambrian (Ozarkian)	Theresa formation	Ch		(20')	Alternating beds of white sandstone, gray calcareous sandstone, and blue sandy limestone, with a 20' sandstone member, the Heuvelton sandstone, near the summit
		Ct		120'	
	Potsdam formation	Cp		0-60'	Mostly white, vitreous sandstone
Precambrian	Grenville series and igneous rocks	Gl Gs gr sy			

Fig. 1 Generalized columnar section of the rocks of the Brier Hill, Ogdensburg and Red Mills quadrangles

Character of the Precambrian surface under the Paleozoics. It has been shown in many of the recent New York reports that Paleozoic deposition commenced upon a Precambrian surface which was characterized by considerable irregularity. This irregularity seems to have been most pronounced on the northeastern margin of the Adirondacks, in Clinton county, and to diminish in amount both to the south and to the west. On the southwest, in

Herkimer county, the irregularity is least, and there, in fact, the surface is quite smooth. Because of abundant rock exposures the phenomena are much better exhibited in the Thousand Islands region than elsewhere, and were described at length in the report on that district.¹ These irregularities amounted to differences of altitude of at least 100 feet in the various parts of the Precambrian surface, the limestones and weaker schists forming the depressions, and the granites and quartzites projecting as the knobs and ridges. This irregularity in surface is just about equal to the greatest thickness of the Potsdam sandstone, the first Paleozoic formation to be deposited upon it, so that the sandstone is very thin on the higher parts of this surface, and the very highest may even project through it.

Since the Alexandria Bay quadrangle corners on Brier Hill at the southwest, it is to be expected that these phenomena will be repeated in the Ogdensburg region. But they are by no means so well shown. The Potsdam seems no thicker here than there, and the irregularity in Precambrian surface seems somewhat greater here. On the Brier Hill sheet, near the river and 3 miles southwest of Morristown, is a small exposure of Precambrian rock, a hard, pyroxenic Grenville quartzite, entirely surrounded by exposures of the Theresa formation, nearly 40 feet above the summit of the Potsdam. This is the only observed case within the limits of the map of Theresa beds on Precambrian, but the Potsdam is very thin, not over 20 feet thick, on the Macomb granite, and it also seems to be thin as the Canton sheet is approached. On the other hand, through Depeyster where it lies on Grenville limestone, it seems at least 80 feet thick.

CAMBRIAN (OZARKIAN) FORMATIONS

Potsdam sandstone. The Potsdam occurs in two different situations, the one as a continuous belt of sandstone bordering the Precambrian rocks on the north, and the other as outliers of sandstone, within the Precambrian area. As the rock characters differ somewhat in the contrasted situations, they are best described separately.

The belt which borders the crystallines is a very irregular one, because of the irregular surface on which it was deposited. The thickness varies greatly, only the upper beds overriding the Pre-

¹ N. Y. State Mus. Bul. 145, p. 54-60.

cambrian ridges, while the lower beds are limited to the depressions. The bulk of the rock is a hard, white, sugary-looking sandstone, locally with a brown tint, composed of nearly pure, quartz sand, thoroughly cemented by silica. The majority of the exposures are of low, flat, glaciated surfaces, and cliffs, or exposures showing any considerable thickness of the formation, are very exceptional. Excellent exposures may be seen to the south of Brier Hill Station, and these expand into a broad sandstone platform to the south on the Hammond sheet. There are excellent exposures also along the west shore of Black lake, above the narrows. Good exposures also occur at the northeast end of the Macomb granite mass, though here the formation shows only the upper 20 feet. Here also are the only actual contacts with the underlying Precambrian which were seen within the map limits. On the Ogdensburg quadrangle, great, bared exposures occur 2 miles south of Heuvelton, and from there run southwest for 3 miles, or rather for several miles, for the same belt continues down into Macomb, giving way to Precambrian just about at the southern edge of the map.

Interbedded with the sandstone on the Alexandria quadrangle is a peculiar conglomerate, whose pebbles are large sized cobbles rather than pebbles, which may reach a foot in diameter and often show a diameter of 3 inches. The pebbles are almost exclusively of Grenville quartzite, and are usually subangular, though well-rounded ones also occur. They are set in a matrix of sand, and the whole is bound together by a cement which is more often calcareous than siliceous, though both sorts occur. Where the cement is calcareous, as it is in the cliff along the St Lawrence below Chippewa bay, the cobbles weather out rather rapidly; where it is siliceous the rock is very resistant. This conglomerate is usually not basal in the formation, but has a varying thickness of ordinary sandstone underneath it. It is a most astonishing formation and difficult of explanation.

This river cliff, containing the conglomerate, continues on to the Brier Hill sheet, in Hammond, as far as Oak Point, beyond which it also appears intermittently. There is a fine exposure of it near Point Comfort, 3 miles southwest of Morristown, where a small fault runs east from the river bank and brings up the conglomerate on its north side, well above the river. It shows precisely the same characters as in Alexandria. Not far beyond the Potsdam dips beneath the bed of the river, after which the Theresa beds are at the river level for several miles. Underneath the conglomerate at

Point Comfort is a 25 foot thickness of Potsdam sandstone to the river level, with the base not reached, a greater thickness of sandstone than was noted anywhere under the conglomerate on the Alexandria sheet. It seems to vary in horizon, instead of being a persistent band, and to exist in the sandstone after the fashion of large channel-fillings. Above it there is a 20 foot thickness of Potsdam sandstone, making altogether a 50 foot section of the sandstone, with the base not seen. This is the thickest continuous section of the formation that we have seen within the map limits.

There is locally a little hard, red sandstone, mixed with the ordinary white and buff rock, more particularly in the exposures along Black lake, but there is no great amount of it anywhere.

At the extreme summit of the Potsdam a thickness of some 10 feet of beds is slightly calcareous. The calcareous cement occurs in rounded patches which have a light, pinkish gray tinge in contrast with the dead white of the rest of the rock, in fresh specimens. But in the ordinary exposures this cement has been leached out, leaving brown-stained spots in the rock. This brown-spotted sandstone is a characteristic feature of the upper beds. It is also characteristic of the sandstones of the Theresa formation above.

The Potsdam sandstone of the occasional outliers in the Precambrian rocks frequently shows phases quite unlike those of the general mass of the rock in the continuous belt. In this respect it accords closely with the outliers on the Alexandria and Theresa sheets which have already been described.¹ Occasional patches of a red, very quartzitic sandstone were found, resting upon Grenville rocks, usually limestone, and extending down into the limestone along joint cracks which had been widened by solution. Other patches of basal conglomerates of the Potsdam were found which contained, along with numerous pebbles of Grenville quartzites, pebbles of this red, quartzitic sandstone. There is no rock in the Precambrian series which is anything like this red sandstone, and the occurrences distinctly suggested a sandstone, older than the ordinary Potsdam, which had largely been eroded away before ordinary Potsdam deposition began.

The Potsdam outliers on the Ogdensburg sheet, which are rather remote from the main mass of the formation, are chiefly found on the surface of the Grenville limestone belt which the Oswegatchie follows for the first 4 miles of its course on the quadrangle. Two

¹ N. Y. State Mus. Bul. 145, p. 61-63.

or three of these outliers consist of red, flinty sandstone quite like that on the Theresa and Alexandria sheets. There are also associated masses of very flinty conglomerate, full of pebbles of Grenville quartzite, and quite like the conglomerate previously described, except for their more excessive induration. These beds certainly appear somewhat older than the Potsdam of the border belt. But there is as yet no decisive evidence of any material difference in age.

No fossils have been noted in the Potsdam of the mapped area. The nearest point at which we have collected them is at Clayton, where *Lingulella acuminata* was found.

Theresa Formation

General statement. A series of "passage beds" of alternating sandstone, calcareous sandstone and dolomite beds overlies the Potsdam everywhere in the circum-Adirondack region. To these beds we have been applying, for mapping purposes, the name of the Theresa formation. In the eastern sections these beds have large thickness, 150 to 200 feet, and are followed by the Little Falls dolomite, the three together forming the upper Cambrian (Ozarkian) series of northern New York. Deposition was seemingly continuous between these formations, and they grade into one another, without sharp boundaries, so that their separation from one another is largely a matter of convention, though they constitute three contrasted, lithologic units.

In mapping the Thousand Islands region we encountered difficulties with this classification. The Potsdam was, as usual, followed by a series of passage bed character, to which we gave the name of Theresa, but no representative of the succeeding Little Falls dolomite is present. In the lower half of the Theresa we found *Lingulella acuminata* in several localities. In the upper half, however, we did not find this fossil but did find in several places a coiled gastropod and occasional cystid plates. These Ulrich identified with forms found in the Tribes Hill limestone of the Mohawk valley, a formation which there lies unconformably on the Little Falls dolomite, and which Ulrich regards as the lowest formation of the New York Beekmantown. The beds containing these fossils were quite similar to the lower ones containing the *Lingulella* and we were unable to detect any break between the two, and hence mapped them together as a single lithologic unit, the two together not exceeding 60 to 70 feet in thickness.

This statement is regarded as necessary here since, in following these beds on to the Brier Hill and Ogdensburg sheets, and tying them up with Professor Chadwick's work on the Canton sheet, it is found that they have greatly thickened, have changed somewhat in character, and that apparently another formation has wedged in between the lower and upper parts of the formation, as shown in the Thousand Islands region. Furthermore the upper part, the Tribes Hill, is shown very sparingly and erratically in the district here, but reappears on the Canton sheet in even greater force than on Theresa. We seem to be dealing with the thin, near-shore edges, of several formations, very similar lithologically, whose thorough discrimination and description is going to be a very difficult matter, and can not yet be successfully attempted, chiefly because of the lack of well-preserved fossils.

Description. As here mapped, the Theresa formation contains at least two different elements. The lower portion of the formation consists chiefly of thin-bedded calcareous sandstones and sandy limestones, blue-gray and very hard when fresh, but weathering rapidly to yellow-brown, porous rocks, such as usually appear in outcrop. Occasional thin beds of white sandstone, usually brown-spotted after the fashion of the uppermost beds of the Potsdam, occur with the others. This material has a general thickness of from 25 to 30 feet, and seems to be the exact equivalent of the typical Theresa of the Theresa quadrangle. It is on the same horizon and looks the same. But we have found no fossils whatever in it in this district, though it should hold *Lingulella acuminata* if our correlation is correct. The zone is, however, seldom well exposed here, and good opportunity for search for fossils is therefore lacking.

Above this thin-bedded zone there is a recurrence of thick-bedded material, with much increase in the amount of sandstone. This is quite foreign to our experience with this passage bed zone elsewhere in New York. In general there is a steady diminution in the amount of sandstone, going up in the section. But here the increase is so marked that, in many exposures, it would be an exceedingly difficult matter to discriminate these beds from the Potsdam, were not the horizon definitely determined. Midway of the zone is a solid mass of sandstone, 20 feet thick, which is so prominent a feature in the geology of the district that we have given it a separate mapping. Professor Chadwick had independently recognized this sandstone on the Canton quadrangle and has suggested

the name of Heuvelton sandstone for it. It is, however, but one out of several thick sandstones zones in the formation; there are three or four others with a thickness of from 8 to 10 feet, which may readily be mistaken for the other where outcrops are poor. Nevertheless the Heuvelton is far the thickest and most prominent of these sandstones, and forms a conspicuous bench wherever rock outcrops are at all plentiful, so that it is readily mapped all across the district, except for that part of its course across the Ogdensburg sheet northeast of Heuvelton, where heavy drift conceals all rock.

Above the 20 foot (Heuvelton) sandstone, beds of sandstone are not so prominent and thick as they are below it, though they persist to the summit of the formation. The chief constituent here, however, is massive beds of hard, blue, coarsely crystalline limestone, full always of sand grains, and of irregular, black seams, or films, of uncertain nature.

Direct contacts of the Theresa with the Potsdam are to be seen at several points along the river cliff above Holmes point and on the south margin of the sheet 3 miles southwest of Brier Hill, and also on the hillside above Black lake, 2 miles west of Kings Corners, at the west edge of the Ogdensburg sheet. These show, in every case, the thin-bedded, alternating sands and calcareous beds of the typical Theresa, with a thickness of about 30 feet. In the latter instance the Heuvelton sandstone directly follows these thin beds. In the other sections a thickness of from 20 to 30 feet of the more sandy, heavy beds lies between. In still other sections this is increased to 40 feet or more. This considerable variation in the thickness of the beds between the Potsdam and the Heuvelton, together with the fact that, in the thinner sections, the beds which are absent are the upper ones, suggests a break between the thin-bedded zone and that which overlies; and it is our belief that such a break exists. But it is a difficult one to locate satisfactorily and, in most sections, we are unable to fix it definitely.

Of the many sections in these upper, sandy beds, containing the Heuvelton sandstone, much the best and most complete one we have seen is the one along the river road, as it climbs the hill just out of Morristown going east. Recent road-making operations there have resulted in exposing an almost continuous section in the road gutter. Necessarily it will show less well as the years go by, but just now it is a very satisfactory exhibition. As our work and that of the road makers was in progress at the same time we had

the additional advantage of having a large quantity of freshly thrown-out rock material to examine. From the river level to the summit of the hill, one mile east of Morristown, a 90 foot thickness of rock is shown in the section, but only the upper 60 feet is in the continuous section. The whole is so homogeneous in its alternations of sandstone, calcareous sandstone, and sandy limestone, that it seems better to generalize and simplify it, than to give the entire, detailed section.

Generalized section at Morristown

- Thin-bedded, light-gray, somewhat magnesian limestone, with frequent sand grains; finely granular; frequent nodules of flesh-colored crystalline calcite, usually small and elongated parallel to the bedding, but sometimes an inch or more in diameter; top not seen; an occasional thin layer of hard, calcareous sandstone is interbedded with it.
-
7. 6' ———
- Thick-bedded, dark blue-gray, very sandy limestone, alternating with grayish white calcareous sandstone, both showing frequent cleavage surfaces of calcite, due to crystalline orientation of the calcite cement; the blue beds are full of thin black films of uncertain nature, irregular but roughly parallel to the bedding; the sandstones are full of fucoidal markings, and both show occasional, large, coiled gastropods.
-
6. 8' ———
- Limestone similar to that above, but alternating with beds of white sandstone which are only slightly calcareous; the calcareous cement is present only in spherical spots, and elsewhere the cement is siliceous; the calcareous cement weathers out, leaving brown, discolored, weathered spots on the otherwise white surface; at many horizons the sandstone is full of films of fine-grained, greenish material resembling clay.
-
5. 7' ———
- Thin-bedded white sandstone, siliceous, but with spots of calcareous cement which weather out leaving round, brown spots; Heuvelton sandstone.
-
4. 20' ———
- Alternating white sandstone and blue calcareous sandstone, the former much in excess; a bed of calcareous sandstone at the base of the 20 foot sandstone, and three others in the interval; remainder all white sandstone.
3. 10'

2. 20' Similar to the division above but with the calcareous sandstone much more prominent, so that it forms half of the thickness; the two alternating in divisions which average 5 feet thick.

-
1. 20' Alternating hard, white sandstone, softer, brown-spotted sandstone, gray, calcareous sandstone, and blue, sandy limestone, in part thin-bedded; less sandy than the divisions above; complete section nowhere shows; this division seems to represent the upper half of the 30 foot division of thin-bedded material at the base of the Theresa; at least it seems to grade into this when followed up the river.

In this section the basal 30 feet of thin-bedded material can not be made out, and the precise horizon of the base determined. But study of the exposures up the river from Morristown suggest that division no. 1 in this section represents the upper half of the 30 foot division, somewhat changed in character and more massive, and that the base of the sections is about 20 feet above the Potsdam.

Judging from the fossil evidence, the upper part of this section should represent a different formation from the true Theresa, and also a different formation from the Tribes Hill, which directly overlies the Theresa in the Theresa region. It is, however, very like the Theresa lithologically and was classed with it while the field work was in progress. In this section our notion is that the 20 feet of beds of no. 1 would be classed certainly as Theresa; that beds nos. 2-6 likely belong to this new formation, and that no. 7 is perhaps Tribes Hill. The large gastropods which are the characteristic fossils of this new division have been found in beds nos. 3-6, so that really the only doubtful division is no. 2. In this connection it is of interest to note possible evidence of a break at this horizon, shown in a railroad cut one and one-half miles southeast of Morristown. The cut shows a 12 foot thickness of beds belonging apparently to the horizon of division 2 of the Morristown section; massive calcareous sandstone at the base, followed in turn by white sandstone and by thin-bedded, calcareous sandstone, and capped by coarse, white sandstone. Following around to the north face of the exposure, these beds are seen to be cut out by a mass of coarse conglomerate, full of sandstone pebbles up to 2 inches in diameter (figure 2). In the field we interpreted this as a channel-filling, but, when taken together with the varying thickness of the

beds between the Heuvelton sandstone and the Potsdam, the 30 feet of divisions 3 and 4 being absent at Black lake, a break is suggested, and probably will be demonstrated on further search.

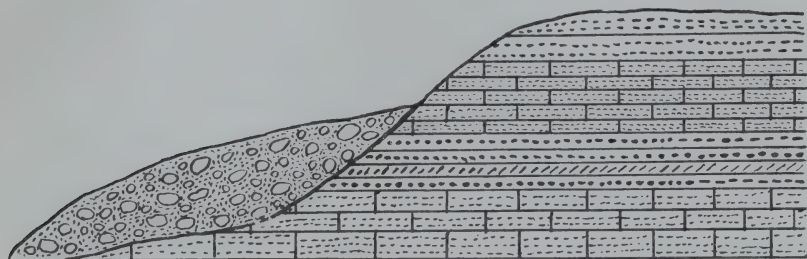


Fig. 2 Exposure in upper Theresa formation $1\frac{1}{2}$ miles southeast of Morris-town, showing the sandstones and calcareous sandstones cut out by a coarse conglomerate. Only one side of this channel-filling can be seen, as the exposure gives out to the east, only a small portion of the original mass of the conglomerate showing.

The fossils. As has been stated, not only the Heuvelton sandstone, but also the beds both above and beneath contain large but poorly preserved gastropods sparingly. So far as our evidence goes, the same fauna runs through all of them. We are much indebted to Dr E. O. Ulrich for the examination of these fossils, upon which he reports as follows:

"The fossils in zones 1-3 (the Heuvelton sandstone and the beds just beneath and above) though poor, indicate at least three, and possibly five species of gastropods: (1) a fragment of a *Sinuopea*-like shell suggesting nothing else so much as a new species of *Sinuopea* from the Upper Ozarkian, Chepultepec dolomite of east Tennessee. Nothing like it is known to me from the Lower and Middle Ozarkian; (2) a narrow, whorled gastropod belonging to a new genus allied to *Liospira*. This species resembles the "*Pleurotomaria hunterensis*" but has a flatter top. A more similar, possibly identical, shell, occurs in the Chepultepec, and in the corresponding Gasconade and Oneota formations, respectively of Tennessee, Missouri, and Minnesota-Wisconsin; (3) a second *Liospira*-like shell, closely simulating a Chepultepec-Gasconade fossil. It also recalls a species of the Beekmantown and Cotter (both Canadian, the latter a new Arkansas-Missouri formation); (4-5) two other, both wider-whorled, *Liospira*-like shells are indicated. Both may be compared with Gasconade species, but similar types also occur in the Canadian and Ordovician."

"As it stands, the faunal evidence indicates almost conclusively that zones 1-3 can not correspond in age to the typical Theresa. The former can scarcely be older than the Gasconade-Chepultepec-Oneota (=Upper Ozarkian), while the latter is surely not younger than early, or early Middle Ozarkian. Apparently zones 1-3 belong to the Little Falls dolomite rather than to the Theresa. If Little Falls—or better, late Ozarkian—overlap took place in the Ogdensburg region, the ensuing sediments would naturally partake of and simulate the sandstone land there prevailing."¹

According to this report of Ulrich's, the fossils point to a late Ozarkian (or Upper Cambrian) age, or else to a Canadian (earliest Ordovician) age. But the remainder of the section here definitely affirms the former as the true solution, since these beds are unconformably overlaid by beds of Tribes Hill age, the Tribes Hill formation being the oldest known formation of the New York Ordovician. Though we have mapped the beds with the Theresa, the Heuvelton sandstone and the beds over that all belong in this new division, as well as a varying thickness of the underlying beds, from 0 to 30 feet in thickness. It will probably be wise to extend the name Heuvelton to include the whole. This division occupies the same interval as that occupied by the Little Falls dolomite of the Mohawk valley, but it is as yet premature to say that it should be correlated with that. The Little Falls follows the Theresa without a break, while there seems to be a break between this Heuvelton and the underlying Theresa.

It is, however, not certain that the Little Falls itself is a single, indivisible formation. The upper, cherty beds at Little Falls and elsewhere contain occasional fossils, especially in the cherts. It was these upper cherts which furnished the fossils described by Hall in volume 1 of the New York Paleontology. The beds contrast rather sharply with the great mass of unfossiliferous dolomite below, and also with the Tribes Hill above. An unconformity separates them from the Tribes Hill. Ulrich has a suspicion that these cherty beds are separable from the Little Falls proper as an upper division, and that a break may occur between them and the main mass of the Little Falls. He is also disposed to correlate the Heuvelton beds with these upper, cherty beds of the Little Falls, because of similarity in the fossils. We have seen all the sections together and I think that this view of Ulrich's has much

¹Letter of October 17, 1914.

to commend it. But additional work needs to be done before this can be put forward as anything more than a working hypothesis. As such, however, it needs to be kept in mind by future workers in the field.

ORDOVICIAN FORMATIONS

Tribes Hill formation

General statement. Blue, sandy limestones containing as fossils "*Pleurotomaria hunterensis*" and cystid plates, identical with forms found in the Tribes Hill formation of the Mohawk valley, were found, with a thickness of some 30 feet, in the Thousand Islands region, and correlated with the Tribes Hill. We were accordingly on the lookout for this formation, while the work on the Brier Hill sheet was in progress, and were much surprised to find little or no trace of it in the excellent sections east from Morristown, while we found instead the considerable thickness of sandy beds containing the Heuvelton sandstone, which have just been described. The small thickness of gray, calcareous beds, no. 7 of the section described on page 31, suggested Tribes Hill, but no fossils were found, and the zone was very thin. Scraps of limestone were also found in poor exposures in the heavily drift-covered portion of the Ogdensburg sheet, also with no fossils. Hence we came to the conclusion that the formation had nearly or quite disappeared in the interval between Theresa and Morristown. In his work on the Canton quadrangle, however, Professor Chadwick found a considerable thickness of beds at this horizon, from which he collected fossils, and for which he suggested a Tribes Hill age. His fossils were determined by Doctor Ruedemann, and subsequently Doctor Ulrich also examined a portion of his collection, and both gentlemen agree in their determination of these beds as of Tribes Hill age. We have therefore mapped a belt of this formation across the Ogdensburg quadrangle, to include the scattered outcrops of limestone. The mapping is, however, of the most perfunctory character since, in that drift-covered belt, no accurate mapping is possible, and geologic boundaries can be delineated only in a most general manner. On the Brier Hill sheet the formation, if present, is so thin and so patchy in distribution that it is impossible to map it on this scale.

This variable distribution of the formation definitely suggests one of two things: either the Tribes Hill shore line in this part of the State was irregular, setting back into embayments on the

Theresa and Canton sheets while the Brier Hill sheet was barely reached by its waters; or else it was deposited on the Brier Hill sheet, and eroded away before deposition of the Ogdensburg division of the Beekmantown commenced. The evidence for deciding between these two views is not at hand. But certain facts do suggest the first view rather than the second. The first of these is that the lithologic character of these beds differs quite materially on Theresa and on Canton; the second is the considerable difference in thickness, coupled with the fact that the beds at Theresa more strongly resemble the middle division of the formation at Canton than they do the basal; whereas if they represented parts of a continuous formation whose summit had been eroded away to varying degree, the remnant left at Theresa should be the basal portion. Our preference therefore is for the view that the Tribes Hill formation is absent from the Brier Hill sheet because it was not deposited there. It should also be noted that Chadwick describes the Tribes Hill base on the Canton quadrangle as coming down almost, locally quite, to the Heuvelton sandstone, while on Brier Hill, 15 to 20 feet of calcareous Heuvelton beds overlie the sandstone. In other words, the Tribes Hill base rests on quite different beds as it is followed across the district, so that the evidence of a considerable break at its base is quite clear. At Theresa it rests on the normal Theresa; at Morristown a considerable thickness of the Heuvelton beds rests on the normal Theresa, and the Tribes Hill, if present at all, rests on the Heuvelton; on the Canton quadrangle it rests on the Heuvelton sandstone, the upper Heuvelton beds being absent, presumably because of erosion antedating the Tribes Hill deposition.

Since the Tribes Hill formation on the Ogdensburg sheet is almost completely drift-covered, a description of the formation can not be written from the exposures here present, and hence we present a short account of the formation as shown on the Canton sheet, which we owe to the courtesy of Professor Chadwick.

Three divisions of the formation are recognized. The lower division consists of mostly thin-bedded, more or less calcareous sandstones, gray when fresh, but weathering to rusty rotten stone. They are ripple-marked, have fucoidal markings on their surfaces, are fine-grained, and vary considerably in the amount of lime, some beds having very little, and some having the characteristic "sand crystal" cleavages which characterize all the rocks from the Theresa up, when the calcareous cement is abundant. Their thickness runs from 15 to 25 feet.

No such beds as these have been seen anywhere on the Brier Hill quadrangle, and they are believed to be totally absent there. It is quite possible that they may exist on the eastern half of the Ogdensburg quadrangle, but no outcrops have been seen, and they are probably wholly covered by drift.

The middle division consists of more massive, less sandy beds, some of which are blue and strongly dolomitic, suggesting the character of the overlying Ogdensburg formation, though everywhere more sandy than the Ogdensburg beds. These beds have a thickness of some 10 feet, and are capped by a hard layer of white vitreous sandstone. Fossils are most numerous and varied in this division.

The upper division consists again of thin-bedded, fucoidal, sandy and siliceous dolomites, quite similar to the beds of the lower division, but more magnesian and less calcareous. They also contain fossils, but less abundantly than the middle division. They have a thickness of at least 25 feet.

In the Raquette river section, at Hewittville, Professor Chadwick finds an additional thickness of some 9 feet of somewhat argillaceous, firm, fine-grained, light-gray limestones and dolomites, with sand grains only in streaks, quite different looking beds from the Tribes Hill beneath, and lying beneath the Ogdensburg beds. They have furnished no fossils. They seem to wedge in toward the east and to be absent in the remainder of the district. It may be suggested that here is the extreme westerly edge of that portion of the Champlain Beekmantown which underlies the Ogdensburg division in those sections.

Ogdensburg Formation

General statement. As has been stated in the preface to this report, the study of the Beekmantown formation of the region was the principal object of the field work. The other formations appearing were known to be those which had already received detailed study elsewhere. But none of the Beekmantown of New York has ever been studied in the desirable detail requisite to furnishing a good idea of its history and its fauna, and almost no study whatever had been previously given in the State to the formation as shown in the St Lawrence valley. It was known to be less fully shown here than in the Champlain valley, and we had predicted that the lower beds would be absent, on the basis of the belief

that the formation overlapped into the district from the east.¹ This proves to be true, in a way, but in a way somewhat more complex than was supposed, owing to the unexpected appearance of the Tribes Hill formation, which we believe to be of oldest Beekmantown age. We do not yet know whether the Tribes Hill formation gets into the Champlain valley at all or not. It is certainly absent at Saratoga, and is apparently absent at Ticonderoga. On the other hand, the lower divisions of the Champlain Beekmantown, division B, division C and the lower portion of division D, are certainly absent at Ogdensburg, as we had predicted.

Nomenclature. The type region for the New York Beekmantown is the Champlain valley, and the work of subdividing and naming the Beekmantown formations of the State should be done in that valley. The work of Brainard and Seely, recognizing five divisions of the formation, which they lettered from "A" to "E," was done a quarter of a century ago, and we do not know whether those subdivisions fulfil modern requirements or not; the faunal zones have not been thoroughly worked out, and the formations have not been named. It was therefore our purpose in this report simply to call the Ogdensburg exhibition of the formation by the group name "Beekmantown," and to leave the application of a name to the future, when it was hoped that a Champlain valley name would be available and applicable. This laudable purpose was defeated by the unexpected presence of the Tribes Hill formation, a Beekmantown formation which had already received a name. In other words, there are two Beekmantown formations here at Ogdensburg, requiring separate mapping and separate designation. Since both are Beekmantown it would be incongruous to apply that name to but one of them. We therefore are proposing the name "Ogdensburg formation" for the upper and more important of the two formations; though we do it most unwillingly, with a premonition that the name will arise to plague us, when the Champlain valley work is done.

Description. By far the best and most complete section of the Ogdensburg formation is that shown along the river west of Ogdensburg, more particularly along the river road, and reaching to within 4 miles of Morristown, where its base is exposed. The most westerly section, shown just north of the roadway, 4 miles northeast of Morristown, is as follows:

¹ N. Y. State Mus. Bul. 145, p. 78, footnote.

3. 15" Gray, granular dolomite, capped by a 3-inch layer of dark blue, magnesian limestone which contains many gastropods; the 3-inch layer is solidly welded to the gray bed beneath.
-

2. 13" Dark blue, sandy limestone, very full of rounded quartz grains, with calcareous cement showing frequent "sand crystal" cleavages; nearly half of the rock consists of quartz sand.
-

1. 12" Gray dolomite, with frequent sand grains, and with some calcareous cement.

These appear to be the very basal beds of the formation. The contact does not show here, but undoubted beds of the Heuvelton calcareous sands come in not far below and, as the Ogdensburg beds are more resistant to erosion, it is probable that this is the very bottom. The sand grains in the two lower layers show that it is near the base, at least. Furthermore, outcrops of the upper Heuvelton in the road gutter, a short distance to the west, show a slightly irregular upper surface, in the depressions of which are patches of sandy dolomite, which are precisely like the basal bed of the section, and which contain, in addition, pebbles of the underlying Heuvelton. These relations indicate an erosional unconformity between the two formations. And this would naturally be expected since, farther east, the Tribes Hill formation wedges in between the two, with indication of a break between it and the Ogdensburg. The so-called upper Heuvelton here consists of a three or four foot thickness of thin-bedded, sandy dolomite which may possibly be itself of Tribes Hill age. No fossils were seen in it and the reference is uncertain. If really Tribes Hill it is but a trifling wedge of the formation, and the break indicated by the exposures is the one between the Tribes Hill and the Ogdensburg, rather than one at the summit of the Heuvelton.

These first exposures of the Ogdensburg formation are about 4 miles northeast of Morristown. Following along to the east no exposures appear within the next mile, owing to a thin, morainic covering, after which they reappear and, except for occasional short gaps, continue all the way to Ogdensburg. The first outcrops, north of the road, show a thickness of 16 feet of the basal beds

of the formation, above the Heuvelton, but the actual base is not well shown. Beyond, the road has an up grade for a mile and an additional 30 foot thickness of higher beds is shown, bed by bed, in the road gutter. Then a rapid down grade, about half way between Morristown and Ogdensburg carries us back through the same beds and, at the foot of the grade a considerable quarry has been opened in the formation, enabling accurate measurement of the beds. The section in the quarry and just above is as follows:

7. 12' Thin, to very thin-bedded, gray, flinty dolomites, with occasional thin bands of blue, crystalline dolomite; occasional fossils, chiefly *Ophileta*.

6. 5' Thin-bedded, gray, flinty dolomite, weathering yellow-brown; often laminated though somewhat irregularly; often thin partings of blackish shale between the beds.

5. 2' 1" Two massive beds of gray, subgranular dolomite with frequent nodules of coarsely crystalline white and gray calcite.

4. 3' 10" Thin-bedded, gray dolomite quite like no. 6 above.

3. 1' 4" Gray, granular dolomite, similar to no. 5 except that the calcite nodules are of smaller size.

2. 7' 4" Dark-blue, finely granular dolomite, often with calcareous cement, "sand crystal" fashion, and with nodules of flesh-colored, coarsely crystalline calcite, often of large size; thick-bedded, seven beds in all; thin partings of blackish shale between the beds.

1. 1' 9" Gray, finely crystalline dolomite; base not seen; lowest layer contains sand grains; irregularly laminated.

33' 4" total thickness

Plate 3 is a view of the beds at this quarry, the massive beds below, and the thinner-bedded material above.

Plate 3



H. P. Cushing, photo, 1913

Quarry showing the lower beds of the Ogdensburg formation, river road, half way between Ogdensburg and Morristown. Beds 1 to 5 of the section in midview, beds 6 and 7 above at the left



Weathered surface of Maclurea layer in Ogdensburg formation in beds just above those shown in plate 3; river road half way between Ogdensburg and Morristown

H. P. Cushing, photo, 1913

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The actual base of the formation is not here reached, but the sand grains in the lowest layer distinctly suggest nearness to the base, certainly not more than 10 feet above it. All the beds contain fossils, the massive blue beds much more abundantly than the thin-bedded gray ones. But the quarry sections are much less favorable places for their observation and collection than are the ledges along the roadway and in the fields. The thin-bedded, gray dolomites at the summit of the quarry contain occasional *Ophiletas*, and are followed above by beds of granular, blue dolomite, some of which are crammed with *Maclureas* and other gastropods, usually in a bad state of preservation (plate 4). They are vastly more fossiliferous than the gray, thin-bedded material beneath. These upper beds are well shown along the road both east and west of the quarry.

It is hardly worth while to describe all the outcrops along the road, and we shall pass over the intermediate ground to a group of quarries, situated about one mile west of Ogdensburg, at varying levels above the river, which when taken together give a nearly complete section of the formation at that point. The two lower quarries are north of the Pythian Home, between the roadway and the river. Beds in the road and near by at the south are added for completion of that part of the section. The other two quarries lie to the east of these and nearer Ogdensburg, and their sections overlap the others.

Section at the Pythian Home

23. 2' 6" Exceedingly massive bed of finely granular, gray dolomite, banded and laminated; forms a massive bench back in the field well to the south of the road; no fossils seen.

-
22. 8' 0" Gap, with beds unexposed, except that midway of the interval is a bed of finely granular, gray dolomite with calcite cement, weathering light brown, and full of small gastropods, *Hormotoma* and allied forms, the only horizon of these seen in the formation; the bed was not seen in place but the material was excavated from a post hole, around which it lay.

-
21. 9" Coarsely granular, dark-blue dolomite with calcite cement of extraordinary coarseness of crystallization, forming "sand crystals" often 2 inches in diameter; layer is full of rounded masses of *Cryptozoon*, which weather more rapidly than the surrounding rock, leaving circular holes which imitate pot holes; the bed is very

fossiliferous above the Cryptozoon, chiefly Eccyliopter-
 us, and the fossils are unusually well preserved.

20. 2' 6" Light-gray to white dolomite, full of quartz sand
 grains, and with a small amount of calcareous cement;
 fairly thick-bedded.
-

19. 1' 8" Massive layer of granular, blue dolomite, with calcite
 cement and fossiliferous.
-

These upper beds are shown in the road gutter and
 the field south of the road, just west of the Pythian
 Home; the beds below are shown in the quarry directly
 north of the road; the Cryptozoon bed at the summit of
 the quarry section shows also in the road gutter, and
 ties the two together.

18. 1' 3" Very finely granular, blue-gray dolomite, with very
 little calcareous cement; frequent small nodules of
 coarsely crystalline calcite; full of masses of Crypto-
 zoon, a different species from the Cryptozoon of the
 Eccyliopterus bed above.
-

17. 1' 1" Solid white sandstone with calcareous cement; it will
 be noted that each Cryptozoon bed is directly underlaid
 by sandstone.
-

16. 6' 0" Massive 18 inch beds of blue, granular dolomite, with
 calcareous cement, weathering sandy-looking, and show-
 ing irregular lines and bunches on weathered edges.
-

15. 3' 8" Massive blue, granular dolomite quite like that above;
 nodules of crystalline calcite; weathers sandy looking;
 has an irregular upper surface with a shale parting
 between it and the beds above.
-

14. 1' 9" Thin-bedded, very finely granular, blue to brown dolo-
 omite, with wavy lamination; weathers irregularly.
-

13. 1' 11" Massive, white sandstone, only slightly calcareous;
 cross-bedded; irregular upper and lower surfaces, and
 welded to the dolomite both above and below.

Plate 5



H. P. Cushing, photo, 1914
Higher beds of the Ogdensburg formation in quarry near Pythian home, showing beds 10 to 16 of the section; the sandstone bed, no. 13 is the second above the quarry floor

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Nearer view of the quarry shown in plate 5, showing beds 11 to 16, the sandstone in midview

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12. 2' 5" Massive blue, granular dolomite, weathering brown.
-
11. 11" Thinner layer of gray, flinty dolomite.
-
10. 2' 3" Massive gray, granular dolomite, to base of quarry.
-

Views of this upper quarry are shown in plates 5 and 6. Directly beneath it, and extending down nearly to the river level is another quarry, carrying the section down.

-
9. 13' Estimate of gap between last, and exposures beneath.
-
8. 2' 6" Heavy bed of gray, finely granular dolomite; weathers brown, with lined edges.
-
7. 1' 2" Thin-bedded dolomite and shale, poorly exposed.
-
6. 1' 9" Massive bed of hard, iron-gray, finely granular dolomite, weathering thin bedded.
-
5. 7' 6" Very solid, massive beds of dark-blue, granular dolomite, beds splitting when weathered; near base a laminated bed, and a shale parting at base.
-
4. 2' 1" A single massive layer like that above, also with a 1 inch shale parting at base.
-
3. 2" Thin layer of flinty, gray dolomite, fucoidal markings on surface, and an irregular base with a shale parting.
-
2. 1' 2" Layer of blue, finely granular dolomite, with Ophileta; a thin shale parting beneath.
-
1. 2' 6" Massive, blue, granular dolomite, to bottom of quarry.
-
- 68' 6" total thickness.
-

We are unable definitely to tie up this section with that 4 miles to the southwest, and given on page 40. We miss here the 20 foot thickness of the flinty, thin-bedded dolomites at the top of that quarry. Beds 3 to 9 of this section may represent this thin-bedded

zone, on the supposition that the thinness of the bedding is only apparent, and due to splitting on weathering, instead of being original. If this be correct, then bed no. 1 of this section corresponds to the upper part of no. 2 of the previous section. In an effort to demonstrate the equivalence, these lower beds were traced southwest for 4 miles along the river and railroad, but a drift-covered belt a mile or more in width intervenes between the two sets of exposures. The heavy blue beds of the base of the section are, however, shown to have a thickness of from 6 to 8 feet and to be full of fossils, chiefly *Maclureas*, and to be underlaid by thin, flinty gray beds, which seem to be the same as those in the quarry section given on page 40, though the full thickness is not shown. Also the *Maclurea* zone above seems to correspond with the very fossiliferous beds above the thin beds of that section, yet it is the summit of this *Maclurea* zone that forms the basal layer (no. 1) of this Pythian Home section. Our opinion therefore is that the one section is entirely below the other, and that the base of the Pythian Home section is some 40 feet above the base of the formation.

In the quarries to the east of the Pythian Home, and on the west edge of Ogdensburg, yet higher beds appear, and the following section was measured:

18. 2' 6" Thin-bedded, finely crystalline, sandy-looking dolomite, of light color slightly tinged with pink; small drusy cavities with tiny quartz crystals; summit beds of the southerly quarry, and above anything in the other.

17. 1' 1" Thin-bedded, blue, granular dolomite; summit bed of the northerly and largest quarry.

16. 6' Thin-bedded, finely crystalline, gray dolomite with calcareous cement of the sand crystal type; many of the beds contain nodules of varying size of white, coarsely crystalline calcite.

15. 1' 9" Massive layer of dark-blue, granular dolomite, calcareous cement of sand crystal type and dark colored.

14. 2' 1" Light-gray, finely granular dolomite, with calcite nodules.
-

13. 1' 1" Massive bed of dark-gray, granular dolomite with irregular upper surface.
-

12. 5' 10" Massive beds of dark-blue, granular dolomite with calcareous cement of coarse "sand crystal" type; nodules of coarsely crystalline calcite in most of the beds which reach very large size in the top bed, many of 8 to 10 inches in diameter, of very coarsely crystalline calcite, much of which is of brown color; holds *Eccyliopterus*.
-

11. 4" Thin bed of flinty, gray, laminated dolomite with very bumpy, irregular upper surface; forms floor of upper division of quarry.
-

10. 1' 1" A 5-inch bed of blue and an 8-inch bed of gray, flinty, brittle dolomite.
-

9. 6" Cryptozoon layer of dark-blue, granular dolomite with coarse sand-crystal cleavages; undersurface very irregular and welded to bed beneath.
-

8. 1' 10" White sandstone with calcareous cement, also with very irregular lower surface, making a 6 inch variation in thickness.
-

7. 2' Two 1 inch beds of light-gray, granular, porous dolomite.
-

6. 9" Thin beds of gray dolomite like that just above.
-

5. 2' 2" Subcrystalline dolomite, iron-gray color and full of ramifying streaks of light gray with a reddish tinge; very brittle and massive; fucoidal markings on upper surface; shale parting beneath.
-

4. 1' 11" Massive bed of dark-gray, finely granular dolomite.

3. 1' 6" Light-gray sandstone with a slight reddish tinge; full of round, floated sand grains set in calcite cement; the layer above should be a Cryptozoon horizon, but none shows here.
-

2. 1' 2" Dark-blue, granular dolomite, calcareous cement, occasional sand grains.
-

1. 2' 1" Massive, dark-blue, finely granular dolomite, resting on a buncy-surfaced layer which forms floor of quarry.
-

35' 8" total thickness.

It is believed that these two sections, the one just given and the one at the Pythian Home, can be definitely correlated by means of the two sandstone horizons. The upper sandstone, with the overlying Cryptozoon bed, nos. 8 and 9 of this section and 20 and 21 of the Pythian Home section, seems a definitely identifiable horizon. The lower sandstone bed is not so certain, as the thickness of intermediate beds is not the same in the two sections. The sandstones are very irregular and seem to shift horizon. Bed no. 13 would seem to be the same as the gray bed at the summit of the Pythian Home section, though thinner here, and there is a thickness of some 13 feet of higher beds, giving a measured thickness of 82 feet for the formation, plus the amount, estimated at 40 feet, which is lacking at the base, but appears in the more westerly sections.

Generalizing the section it may be said that it consists chiefly of three types of rocks, the granular, dark-blue beds with calcareous cement, and with the most frequent fossils, the finer grained, dark-gray beds, and the thin-bedded, flinty dolomites. A small thickness of basal, sandy beds is followed by a thickness of some 15 feet of the blue beds, above which is a prominent zone of thin-bedded dolomite some 20 feet thick, while the remainder of the section consists chiefly of alternations of the dark-blue and dark-gray beds, together with an occasional thin sandstone, generally in association with a Cryptozoon bed. The zone of these sandstones, and the 20 foot zone of thin-bedded dolomites near the bottom, are the only ones of sufficient definiteness to be used in horizon determinations. For the remainder the beds are very uniform in their character and their alternations, and the horizon of isolated outcrops is invariably a very uncertain matter.

In regard to their fossil contents also, the comparatively few forms which are abundant seem to run through the whole section, and fossil zones which are sufficiently restricted and sufficiently individualized to serve as markers for a particular horizon in the formation do not seem to be common. Ulrich went over the section from Morristown to Ogdensburg with us, collected fossils from it which he has compared with the material in his own large collections from Missouri and elsewhere, and generously contributes the following report upon them.

Zone 1 (zone 4 of Ulrich's section, zones 1-3 being in the Heuvelton beds below) of fossils from the quarry section of the lower beds, given on page 40, and chiefly from the thin-bedded, upper portion:

Lingula sp. undet.

"*Ophileta*" *grandis* Ulrich. A widely distributed species marking the Roubidoux (basal Canadian) formation in Missouri. Shell larger, whorls expand more rapidly, and carina more nearly peripheral in position than in *O. compacta* Salter (= *O. complanata* Whitfield, not Vanuxem).

Generically undetermined trilobite. (Collected by Chadwick, only one specimen seen.)

This is not the lowest fauna of the formation, since the heavy, blue beds beneath contain a fairly abundant fauna, which is, however, difficult of collection and determination, since seen only on glaciated surfaces. The species seem the same as those of zone 2. My own collection shows that "*Ophileta*" *compacta* Salter occurs in zone 1, in addition to the forms listed. "*Ophileta*" *grandis* Ulrich is the commonest fossil, however.

Zone 2 (zone 5 of Ulrich), the blue beds which follow above the thin-bedded dolomites of the previous zone, and are crammed with fossils, usually poorly preserved (plate 4).

Tryblidium cf. *ovatum* Whitfield

Maclurea (?) cf. *transitionis* Billings

Maclurea (?) cf. *oceanica* Billings

Maclurea (?) cf. *affinis* Billings

Liospira (? *Ophileta*) aff. *hunterensis* Cleland

Liospira (? *Ophileta*) sp. cf. *Raphistoma praeivium* Whitfield

Liospira sp. 3 (has more rapidly expanding whorls and smaller umbilicus than two preceding species)

"*Ophileta*" *compacta* Salter

In addition, a few feet above the most fossiliferous bed of this zone is a thin bed (zone 2a, 5a of Ulrich) filled with *Syntrophia lateralis* Whitfield.

Above zone 2 fossils are comparatively scarce, though apparently of these same species through a thickness of some 30 feet of beds, when the two *Cryptozoon* horizons are reached (beds 18 and 21 of the Pythian Home section). From bed 18 we collected no fossils aside from the *Cryptozoon*. But bed 21 contains the best preserved fossils obtained from the entire section, lying above the *Cryptozoon* masses, and evidently inhabiting the reef. Good material can be collected only from somewhat weathered rock. In freshly quarried material the fossils break across.

Zone 3 (zone 6 of Ulrich) *Eccyliopterus* zone.

Cryptozoon sp. undet. (cf. *C. minnesotensis* Winchell)

Eccyliopterus planidorsatus Ulrich

Eccyliopterus planibasalis Ulrich

Endoceras montrealense Billings

Cameroeras (?) (siphuncle only, strongly annulated)

Involute cephalopod of undetermined genus

Of this fauna *E. planidorsatus* is the common form, outnumbering *E. planibasalis* by 5 or 6 to 1. Annulated cephalopod fragments are not scarce, but the *Eccyliopterids* are the abundant fossils.

Zone 4 (7 of Ulrich), *Hormotoma* zone, only a few feet above zone 3.

Hormotoma gracilens Whitfield,

Turritospira cf. *anna* Billings and *confusa* Whitfield.

This thin layer is crammed full of these small gastropods, and likely several other species can be identified when the fauna is thoroughly studied.

Ulrich comments on the fossils as follows: "Apparently all these zones belong above division C and beneath division E of the Champlain section. Stratigraphically then, they occupy the position of division D. The fauna of division E is not even suggested, while none of the species are of those which particularly characterize the fossil beds at Fort Cassin. The latter, I believe, belong between typical D and E. Hence the Ogdensburg dolomite seems to correspond exactly, or at least essentially, to division D."¹

¹ Letter of January 13, 1915.

It was our hope that, by carrying our work down the river below Ogdensburg, this section could be extended upward. In this respect we were completely disappointed. The drift is so heavy below Ogdensburg, and the outcrops so rare and so poor that, with the lithologic similarity of the beds, no certainty as to their position could be arrived at. The best section seen east of Ogdensburg is at Red Mills, 6 miles farther down the river, where a 20 foot thickness is exposed, the basal layer appearing in the river bed and causing the Galop rapids in the river. The section here is:

Four solid layers of blue, finely granular dolomite,
10. 4' 8" weathering on edges in horizontal, wavy lines; small calcite nodules; much coarser grained than the beds below.

9. 1' 8" Blue-gray, hard, flinty dolomite, thin-bedded, upper 2 inches very shaly.

8. 2' 4" Two beds of massive dolomite, otherwise like that above.

7. 2' 1" Light-gray, hard, *very* finely granular dolomite, with small drusy cavities containing calcite; weathers drab; two beds.

1' 6" Unexposed.

6. 1' 3" Light-gray, flinty dolomite, excessively fine grained.

5. 3' 4" Dark-blue, flinty dolomite, of very fine grain, in 6 inch layers.

4. 10" Gray, fine-grained dolomite, weathering yellow-brown; irregular surface.

3. 1' 1" Hard, dark-blue dolomite, like no. 5; finer grained than no. 4.

2. 1' Unexposed.

1. 1' 1" Single layer of thick, hard, *very* finely granular, gray dolomite at river edge and in river; base not seen.

20' 10" total thickness.

This section does not correlate with any of the beds seen in the Ogdensburg section, where there is nothing resembling such a thickness of thin-bedded, flinty dolomites, wholly unmixed with the granular, dark-blue beds with calcite cement which make the larger part of the upper section there. We are therefore forced to conclude that this section lies above anything seen at Ogdensburg, and that it can not be much higher. The dip in the district is to the north, as will be shown; but it is not high. Red Mills is about 3 miles farther north than Ogdensburg, and 6 miles farther east. The summit beds of the section at Ogdensburg are 80 feet above the river. Judging from the rate at which the Heuvelton and the lower Ogdensburg beds pass beneath the river level between Morristown and Ogdensburg, and assuming that the rate remains the same below Ogdensburg, the upper beds of the Ogdensburg section should have just about reached the level of the river at Red Mills. We feel therefore reasonably secure in stating that this thin-bedded dolomite zone at Red Mills almost directly overlies the beds of the Ogdensburg section, and that their 20 foot thickness should be added to the thickness of the formation.

Elsewhere on the Red Mills sheet outcrops are exceptional and show no great thickness of rock. But all the outcrops seen are of the same type of rock as at Red Mills, hard, flinty, fine-grained dolomite. The rock is very unfossiliferous, not a sign of a fossil having been seen on the Red Mills quadrangle. In this respect also the rock differs from the lower beds shown west of Ogdensburg. The most northerly exposure seen, on Rockaway point, north of Tilden, is nearly 5 miles farther north than the section at Red Mills, and should therefore represent a considerably higher horizon. A single, massive bed of gray, flinty dolomite is, however, all that is shown.

Summary of section of Ogdensburg formation. The reporting of detailed sections furnishes a dreary job for the general reader, hence the details are here briefly summarized.

Between Morristown and Ogdensburg all the beds of the lower portion of the formation are shown, with a thickness of some 120 feet. The base lies unconformably on the underlying beds, and the lower beds contain sand grains. Some 15 feet of granular, blue, calcareous dolomites follow, then 20 feet of thin-bedded, fine-grained, gray beds, weathering brown. Above come 80 feet of alternating dark-blue, granular beds, and dark-gray, more finely granular beds, of dolomite with calcite cement. All the beds are

fossiliferous, sometimes abundantly so. Above these, separated by an unknown but probably small interval, follow the gray, flinty beds of the Red Mills quadrangle, very unfossiliferous and of unknown thickness. The section shown seems to correlate with division D of the Champlain section. Further work down the river may show somewhere a good section of the higher beds, so that the section may be completed and the full character of the Beekmantown group of this district shown, but the whole valley is so heavily drift-covered that we are not sanguine that this can be successfully done. The formation extends down the river for many miles more before the overlying Chazy beds appear, the Ottawa basin Chazy. It is very doubtful if these beds get over into New York at all. But in any event the indications are that a considerable thickness of Beekmantown beds higher than those in the Ogdensburg region must be present.

In New York State Museum Bulletin 145 we made certain predictions concerning the age of the Beekmantown formation of the St Lawrence valley based on the results of the Thousand Islands work and of our much earlier reconnaissance work farther east, particularly around Potsdam.¹ The results just outlined in the discussion of the Ogdensburg formation seem to us to fulfil those predictions. We argued that the first Beekmantown to appear down the river from the Thousand Islands should not be the lowest division of the formation in the Champlain valley, but of higher beds. The basal beds prove to be of the age of division D, with divisions C and B entirely lacking. There is also a break between them and the beds directly underneath, as we argued should be the case, a break not only shown by a basal conglomerate and sand grains in the basal dolomite, but also by the fact that the beds just underneath vary much in horizon across the district. So far the results of this study accord with expectation. The unexpected results are the continued presence of the Tribes Hill formation underneath, and the entirely new division represented by the Heuvelton beds. Our work has shown an unconformity between the Ogdensburg and the Tribes Hill, and Chadwick's work on the Canton sheet shows a break between the Tribes Hill and the underlying Heuvelton. We have not demonstrated a break between the Heuvelton and the underlying Theresa, and have mapped them together, but it is quite likely that a break exists. The work of

¹ Pages 92-96.

the past fifteen years on the Paleozoic rocks which rim the Adirondacks has shown clearly that they consist largely of the thinned, near-shore edges of a great number of formations, and that there is a great lack of correspondence between the formations on the different sides of the region. The Heuvelton division found here adds yet another unexpected member to the group. Or, as Ulrich writes, "Evidently the western flank of the Adirondack uplift carries more of these thin wedges than we supposed." No doubt yet others remain to be found.

Structures of the Paleozoic rocks

Dip. The dips of the Paleozoic rocks of the Ogdensburg region are low, seldom exceeding 5° , and are in a general northerly direction. On the Brier Hill quadrangle they average somewhat to the west of north; on Ogdensburg they are more nearly north. Along the river between Morristown and Ogdensburg the Heuvelton and Ogdensburg beds disappear under the river at a rate of from 25 to 30 feet a mile; that is, a mile in a northerly direction; in the northeasterly direction of the river's course the rate is slower. This is not a high dip, but a very low one, and has no particular interest except in its contrast with the southwest dip which the Paleozoic rocks of the Theresa and Clayton quadrangles, on the other side of the Frontenac axis, possess.

Folds. In the Thousand Islands report it was shown that the gently inclined Paleozoic rocks of the region had been somewhat folded, and that there were two sets of gentle folds whose axes cut one another almost at right angles, the one set trending somewhat east of north, and the other somewhat north of west.¹ The effect of this double folding was to produce an alternating series of low domes and low basins in the rocks, domes at the intersections of anticlines, and basins at the intersections of synclines of the two sets of folds.

This same type of folding carries over into the Ogdensburg region, though the evidence is not so clean-cut here because of less frequent exposures. But low domes of rock, from the summit of which the dip falls away to all points of the compass, are of quite frequent occurrence. The corresponding basins, occupied by outliers of younger formations, which were such a feature of the geology of the Theresa and Clayton sheets, are not easily detected

¹ N. Y. State Mus. Bul. 145, p. 112-15.

about Ogdensburg, partly because sharply contrasting, thin formations are not present here, and partly because of drift-covering. The areal mapping suggests that the axes of the folds have swung to northeast and northwest directions, and that the northeast set is much more prominent than the northwest set in the Ogdensburg region.

Faults. Faults are scarce in the Paleozoic rocks of this northwestern region, though they increase in number and importance in passing to the east. In the Ogdensburg region we have noted but one fault of any prominence, at Point Comfort, 3 miles up the river from Morristown, Brier Hill sheet. The fault bears east and the south is the downthrow side. Above Point Comfort the river cliff is composed of the Potsdam and Theresa formations, 10 feet of Potsdam which has increased to 20 feet at Oak point, overlaid by the thin-bedded, calcareous sandstones of the typical Theresa. This is the section south of the fault, the downthrow side. North of the fault the Potsdam extends up to 50 feet above the river, with a great bed of its characteristic coarse conglomerate, the same bed that occurs in the river cliff in Hammond township. At the fault 25 feet of sandstone show below it, and 20 feet above it, followed by the Theresa. The throw of the fault here is about 40 feet. The fault zone shows no outcrops but is occupied by a drift-filled depression, as is apt to be the case. It can not be definitely traced inland, away from the river because of infrequent outcrops and of similar Theresa beds on both sides. But 2 miles to the east, along its supposed trend, there is evidence of misfit in the strike of the bed of 20 foot (Heuvelton) sandstone, on the two sides of the line, so that in all likelihood the fault extends east at least to this point.

A very trifling fault is shown along the river road $2\frac{1}{2}$ miles below Morristown, where the road runs over a shallow gully and small stream. The 20 foot sandstone of the Heuvelton is dropped in level about 15 feet on the east side of the gully as compared with its level on the west side, and is apparently faulted down. It is a trifling break and can not be traced to the south.

Except for these two, no faults have been noted.

HISTORICAL GEOLOGY

PRECAMBRIAN TIME

Recorded geologic history began in New York with the deposition of the Grenville series. That this was not the actual beginning of the history of the region is shown by the fact that the Grenville,

a series of water-deposited rocks, must have been laid down on some floor of preexisting rocks. So far as we can find, no trace of this floor remains and we are in entire ignorance as to its nature. That there must have been a long period of time anterior to this in the earth's history, we are certain, but we entirely lack direct evidence regarding it.

The Grenville is an enormously thick sedimentary series, comprising masses of limestone, of shale and of sandstone. It is so thick and so varied that it is quite probable that it comprises more than one formation. To deposit such a thick accumulation of sediments must have required a very great lapse of time. The Grenville is as old a rock series as is anywhere known.

Following the Grenville the region was invaded from beneath by enormous masses of molten rock which were working their way upward toward the surface. They badly broke up the Grenville deposits, thrusting their way through them, pushing them aside, and likely wholly engulfing great masses of them. This intrusion, and those which followed, are no doubt chiefly responsible for the disappearance of the old floor of deposit of the Grenville. The intrusive consisted of granite. It greatly added to the pressures and the temperature of the invaded rocks, and was an important factor in changing them into the crystalline rocks of which they, today, consist. The Grenville rocks today invariably rest upon these intrusives, which are nevertheless younger, in spite of the fact that they underlie them.

The Grenville rocks and the Laurentian granites (as these early granitic intrusives are called) are early Precambrian. Elsewhere, in Ontario and the States which border on Lake Superior, other and younger Precambrian formations are found; at least three great series of formations younger than the Grenville, aggregating many thousand feet in thickness, and separated from one another by profound unconformities, representing times of uplift and of erosion, times apparently as long as those in which the deposits were being laid down. Erosion is a slow process; so is deposition; yet thousands of feet in thickness of deposits were formed, and a vast amount of material was eroded during that part of the Precambrian which followed the Grenville.

These younger Precambrian rocks, that is, younger than the Grenville and the Laurentian granite, are, in their turn, accompanied by, or cut by, intrusives, which are younger than they are. Younger intrusives are also present in the Adirondacks, though the sediments are lacking. A great series of intrusives, anorthosite,

syenite, granite and gabbro, have wide extent in the Adirondacks, particularly on the east and south. They aided in altering and metamorphosing, as well as in breaking up and destroying, the older Grenville and Laurentian. The small masses, mapped as syenite, on the Ogdensburg quadrangle, we refer to this second period of eruptive action.

The latest of the Precambrian rock series of the upper lake region is accompanied by great flows and sheets of trap. The trap dikes of late Precambrian age in the Adirondacks are of similar rock and are naturally correlated with them. Only one such dike has been found in the Ogdensburg region, but they are abundant farther up the river, in the islands. Not only do they cut all the other Precambrian rocks, but they are entirely unmetamorphosed, indicative of a long time gap between them and the older rocks.

There is no evidence that any of these later series of Precambrian sediments were ever deposited in the Adirondack region, though it is entirely possible that some of them may have been laid down, and subsequently completely removed by erosion. There is no evidence to controvert the statement that the Adirondack region was a land area throughout all the great lapse of Precambrian time following Grenville deposition, and that this portion of its history is one of erosion rather than of deposition. A great thickness of Grenville and of igneous rock was worn away, and the region was reduced to the condition of a comparative plain, whose surface irregularities were of a minor sort, and seem not to have exceeded 200 feet in amount. Within this minor degree, however, the surface was fairly rough, the weak rocks worn down into valleys and the more resistant ones projecting as low hills and ridges. The intrusion of the traps came toward the latter end of this long period.

CAMBRIAN TIME

The erosion period just mentioned involved the greater part of Cambrian time in addition to the long Precambrian interval. But in the latter part of the Cambrian all four sides of the Adirondack region became depressed and deposits began to form on the old erosion surface. Deposit began on the northeast, with coarse conglomerates, followed by sand, forming the initial deposits of the Potsdam sandstone. These early deposits have furnished no marine fossils and strongly suggest continental formations. In their lack of thorough decay they also suggest climatic aridity. As time went on the deposits gradually extended to the south and the west of

the initial region, up the Champlain and the St Lawrence troughs. And these upper beds of the formation are marine in origin, as their fossils show. In the Ogdensburg region only a thin, upper portion of the formation was deposited, its thickness barely equaling the irregularity of the floor on which it was laid down, so that it does not appear at all on the higher parts of the old, Precambrian surface.

The passage to the Theresa was a gradual one, the sand supply lessening, and calcareous matter increasing. The fauna remained substantially the same.

The Theresa *seems* to graduate upward into the Heuvelton without any break; at least we have, so far, failed to detect one. But there is a prominent change in the fauna, which Ulrich compares to that of the uppermost portion of the Little Falls dolomite of the Mohawk valley. We are still in doubt as to just what the history was at this stage. The fauna is a comparatively unknown one in New York, and there is nothing in the St Lawrence region which can be directly correlated with the thick Little Falls dolomite of the Mohawk and Champlain valleys, which there follows the Theresa without a break. Whether the Heuvelton is a thinned representative of the Little Falls, of quite different lithologic character because of deposit in a separate basin, whether it is younger than most or all of the Little Falls and represents a deposit of an age hitherto unknown in the New York section with a break between it and the Theresa representing Little Falls time, or whether there is no break, and the Potsdam and Theresa of this region were being deposited at the same time that the dolomite was forming in the Mohawk region, can not yet be told. One or the other of the three no doubt represents the true condition of affairs.

ORDOVICIAN TIME

There is a distinct break between the Heuvelton and the overlying Tribes Hill formation in the Ogdensburg region, and such a break seems everywhere to mark the close of the Cambrian in New York. We are therefore justified in concluding that marine waters were completely withdrawn from the region for a time. Slight warping of the surface took place and a very moderate amount of wear occurred, so moderate as to indicate that the land was of low altitude. Then the sea returned and Tribes Hill deposition commenced. This formation runs all through the Mohawk valley with considerable prominence. It is absent in the Black river valley, but reappears as a thin wedge in the Theresa region, is absent on Brier

Hill and again returns with increased prominence east of Ogdensburg, running at least as far as the Raquette river. How much farther down the St Lawrence valley it may go, is today unknown. The formation is not known in the Champlain valley, though it may exist there. But it is now certain that the Tribes Hill waters bordered the Adirondacks on the south, west and north sides.

At the close of the Tribes Hill there was oscillation of the district, bringing the whole above sea level following which the Champlain valley region alone was depressed, and deposition of Beekmantown divisions B and C began there. As Beekmantown time went on this Champlain depression began also to involve the St Lawrence trough, extending westerly up that trough until the Ogdensburg region was reached, and deposit of the Ogdensburg formation, division D, began. This depression no doubt continued through the remainder of Beekmantown time, the Champlain and St Lawrence valleys below, the Black and Mohawk valleys above sea level, all Beekmantown formations other than the Tribes Hill being absent on the south and west sides of the Adirondacks. At the close of the Beekmantown the sea was withdrawn from the whole region.

There is no direct evidence of the deposit of any of the later Ordovician formations in the Ogdensburg region, but it is highly probable that the thinned edges of several of them were laid down here. The Pamela formation of the Theresa region may have come as far east as this; outcrops of the Ottawa Chazy come in above the Beekmantown not a great many miles down the St Lawrence on the Canada side, and may well have reached farther west. Some of the various Black River and Trenton formations may likewise have been laid down, and this is also possible in regard to the upper Ordovician shales. But the Frontenac axis was early outlined as a barrier between the St Lawrence and Black river troughs of deposit, and it is not believed that any of these formations could have had any large thickness in the Ogdensburg region. So far as now known there is not a scrap of reason for believing that any Paleozoic marine rocks younger than the Ordovician were ever laid down here.

LATER PALEOZOIC HISTORY

During Silurian, Devonian and Carboniferous times the region no doubt experienced oscillations of level, as during its previous history. But the downward movements do not seem to have carried it below sea level. It seems to have persisted as a low altitude area, so low that erosion of its surface was but slight, but not low

enough for marine invasion. From time to time it may have received a coating of continental deposits, in fact the Oswego sandstone may have been deposited here in considerable thickness; but all trace of these is now gone. We are, however, obliged to assume the original presence here of formations younger than the Beekmantown for the reason that some considerable thickness of rock has certainly been eroded away from the region in the vast lapse of time since the Ordovician. The most probable of such formations are those whose present-day outcrops lie nearest the region, such as the Pamelia, Chazy, Black River and Trenton, Lorraine and Oswego.

During all of Paleozoic time the Adirondack region seems to have persisted as a continuous land area, submerged frequently on one or more sides; seldom or perhaps never on all four sides at once, and the interior probably never submerged at all.

No doubt the district participated in the considerable uplift of the eastern part of the continent at the close of the Paleozoic, the so-called Appalachian revolution, when it may for a time have had an altitude of many hundreds of feet above sea level. But the St Lawrence valley has always had a tendency to sag, as compared with the territory to the north and south. How much this inherent tendency may have counteracted that uplift, it is impossible to say.

MESOZOIC HISTORY

In common with all the eastern portion of North America, with the exception of a narrow, marginal strip along the Atlantic and Gulf coasts, the Ogdensburg region was a land area and undergoing wear. In this long interval the erosion was so great that the entire area was apparently worn down to a comparative plain, or peneplain. No trace of this peneplain remains in the Ogdensburg region, as subsequent wear has entirely obliterated it; but there is strong probability that it was produced here.

TERTIARY HISTORY

Uplift of the region followed after its peneplanation, and erosion began the development of another peneplain. During the Tertiary there was more than one such oscillation, during which the district underwent partial peneplanation. A great peneplain level is today discernible in the even levels of the hilltops of the western Adirondacks, of the Oswego sandstone plateau, and of the plateau region of southern New York. This may represent the Cretaceous pene-

plain; or it may represent one of the later ones. Much work remains to be done before more definite statements regarding the history of the region during this long lapse of time will be warranted.

QUATERNARY HISTORY

Another upward movement of the region occurred toward the close of the Tertiary and the present low grounds of the region have been worn down below the level of the previous peneplain, since that occurred. Glaciation of the region followed, a series of ice sheets invading it, advancing, reaching a maximum, waning and disappearing, and separated from one another by long, interglacial intervals. There were certainly three such ice sheets, and very probably five or even six, which followed one another over the district. The later ones largely obliterated the traces of the earlier. The glacial deposits of the region consist chiefly of those left by the last retreating ice sheet, and the polish and striation of the underlying rock are chiefly also of that date, though in some places the rocks bear two sets of striae, the one superimposed on the other.¹

The last ice sheet retreated from the district toward the northeast. It vanished from the Ogdensburg vicinity while it still remained blocking the St Lawrence valley lower down. The district also had sagged in level during the Glacial Period and was at a level some 400 feet or more below its present-day altitude. The lake waters which collected behind the retreating ice front could not pass down the St Lawrence valley because of the ice blockade lower down, and they rose until they found an outlet down the Mohawk valley to the Hudson. This lake, known as Lake Iroquois, occupied the Ontario basin, extended east to Rome, N. Y., where its outlet began, and extended itself down the St Lawrence valley behind the retreating ice wall. It has left a well-defined shore line all around Lake Ontario, distinctly recognizable as a continuous beach to a point some 5 miles east of Watertown, Cape Rutland, where its altitude, a terrace and cliff on the limestone nose of the promontory, is at 733 feet above sea level. This old shore line has

¹ The glacial striae which have been observed in the region are indicated upon the geologic maps. The usual direction shown is south, from S. 10° W. to S. 10° E. showing that to be the general direction of the latest ice motion. The older striae, however, trend from S. 40° W. to S. 30° W. Whether these were produced by an earlier ice sheet, or during an earlier stage of the last ice sheet, is not yet definitely established, though quite probably it was the former. There is considerable evidence to the effect that the action of the last ice advance in the region was very feeble, erosively.

been tilted since its formation, rises in elevation toward the north, and Fairchild estimates its altitude at some 900 feet at the south edge of the Brier Hill sheet. East of Cape Rutland, owing to the broken and uneven character of the country along the north side of the Adirondacks, this shore line is much broken and difficult to trace. But even the altitude at Cape Rutland is far above any elevation on the Brier Hill and Ogdensburg quadrangles, which were therefore covered for a time with the fresh waters of this lake, waters over 500 feet deep on these quadrangles. The moraines left by the retreating ice were deposited underneath these waters.

As the ice retreated down the valley and neared the Champlain region, the lake waters began to find outlets to that valley between the ice front on the north and the valley walls on the south, and the level of the lake began to fall. Successive stages were passed through until finally the ice entirely unblocked the valley, and the waters fell to an altitude estimated at some 450 feet, using Fairchild's figures.¹ Even this altitude would carry the water to the very top of Mount Lona, the highest point on the Ogdensburg quadrangle. And at this level, and the lower ones which succeeded it, the whole surface of the district would have been subjected to the leveling effect of wave action, laying bare surfaces of hard rocks, and filling hollows with water-laid clays.

At this stage the fresh waters of Lake Iroquois were succeeded by the brackish waters of a marine estuary, the lower altitude of the region permitting the marine waters of the Gulf of St Lawrence to extend up the valley to Lake Ontario, involving the lake itself in this marine extension. The marine fossil shells buried in the deposits of these waters have been found as far west as Ogdensburg, and farther east are abundant. Those found near Ogdensburg have all been on low grounds, only 30 to 40 feet above the river, but at Norwood, Woodworth reports them at elevations of from 335 to 360 feet.² The clays and sands containing these shales were obviously laid down below the marine level. The lack of these fossils west of Ogdensburg is likely due to the water not being sufficiently salty there.

In the few thousand years that have elapsed since the marine waters were in the region at their highest stage, a slow uplift has been in progress, an uplift most prominent at some point well to the northeast of Ogdensburg. This uplift not only slowly brought this

¹ N. Y. State Mus. Bul. 145, p. 139.

² N. Y. State Mus. Bul. 84, p. 208-9.

district above sea level, and carried the end of the St Lawrence estuary eastward to its present position, but also tipped the old shore lines of the vanished bodies of water, so that today they are no longer horizontal, but have a slowly increasing altitude as followed northeast. The entire Ogdensburg quadrangle is too low to exhibit any of these main shore lines.

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ALBANY, N. Y.

DECEMBER 1, 1916

The University of the State of New York New York State Museum

JOHN M. CLARKE, DIRECTOR

GEOLOGY OF THE BLUE MOUNTAIN, NEW YORK, QUADRANGLE

BY WILLIAM J. MILLER

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The University of the State of New York

Department of Science, July 10, 1916

Dr John H. Finley

President of the University

SIR:

I am transmitting to you herewith a manuscript entitled "The Geology of the Blue Mountain Quadrangle" with the necessary maps and illustrations. This is a report of special investigations carried on for this Department by Dr William J. Miller and I recommend that it be published as a bulletin of the State Museum.

Very respectfully

JOHN M. CLARKE

Director

UNIVERSITY OF THE STATE OF NEW YORK

OFFICE OF THE PRESIDENT

Approved for publication this

11th day of July 1916

A handwritten signature in dark ink, appearing to read "John H. Finley". The signature is written in a cursive style with a horizontal line underneath.

President of the University

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GENERAL GEOGRAPHY AND GEOLOGY

The territory covered by the Blue Mountain quadrangle¹ lies in the heart of the Adirondack mountain region and all in northern Hamilton county excepting less than 2 square miles of its northeastern corner which extends into Essex county. It comprises an area of nearly 215 square miles. The geographic center of the 10,000 square miles of Precambrian rock in northern New York lies within, or close to, the northern portion of the quadrangle. The region is very typical of the great Adirondack wilderness, being rough, well watered, densely wooded, sparsely settled, and with few traveled roads or trails. The difficulties of making a systematic geological survey of such a region, especially those portions where forest fires have wrought havoc, are not easily exaggerated. It is a pleasure to record that several of the writer's former students of geology — Messrs J. P. Hull, H. Insley, and L. W. Bissell — at different times accompanied him into some of the roughest country and rendered valuable assistance.

The only villages in the area are Indian Lake, Blue Mountain Lake, and Long Lake, no one of which has more than a few hundred residents. Most of the comparatively little farming of the region is confined to the vicinities of these villages and along Cedar river. Lumbering is still an important industry, though much of the first-growth timber has been cut. During the summer

¹ See map in pocket of back cover of this bulletin.

seasons hundreds of people go to the hotels or occupy cottages on Long lake and Blue Mountain lake.

No railroad enters the quadrangle, the nearest one being the Raquette Lake Railroad branch of the New York Central (Adirondack division) with terminus at Raquette Lake village about 8 miles from the western edge of the quadrangle. The traveled roads are clearly shown on the accompanying map. It is of interest to note that fully one-third of the area of the quadrangle (or about 75 square miles), including the northern-central and eastern-central portions, is wholly without a used or well-defined road, or even trail.

The maximum range of altitudes within the map limits is from a little less than 1560 feet, where Cedar river leaves the map on the east, to 3759 feet at the summit of Blue mountain. Ranking next in altitude are the two summits of Dun Brook mountain, 3580 and 3565 feet respectively, and Fishing Brook mountain, 3550 feet. The largest, high, rugged mountain group occupies some 35 or 40 square miles bounded by Mount Sabattis on the west and Fishing Brook and Dun Brook mountains on the east. At least 15 points within this group reach altitudes of 3000 feet or more. In the southeast, Blue Ridge and the prominent ridge just south of it show altitudes of over 3000 feet, the maximum figures being respectively 3481 and 3350 feet. Along the central-southern border, two points attain altitudes of about 3150 feet, these really being only on spurs of the Panther mountain mass of the northern part of the Indian Lake quadrangle. As compared with the eastern and southeastern Adirondacks, there is no very prevalent trend of mountain masses, though there are some suggestions of the usual northeast-southwest strike.

An important division of drainage — that between the Raquette and the Hudson rivers — passes across the quadrangle. Beginning at the middle of the northern boundary of the quadrangle, this watershed passes over Burnt mountain, Fishing Brook mountain, the northern summit of Dun Brook mountain, Buck mountain, Blue mountain, less than a mile south of Blue Mountain and Eagle lakes, and along the crest of Blue Ridge to the western border of the area. This watershed marks essentially the crest of the central portion of what has been called the main axis of elevation of the Adirondack region. Two valleys (below described), with greatest altitudes of only about 1800 feet, cut completely across this axis within the quadrangle and constitute two of the three or four lowest valleys

Plate I



Blue mountain (altitude 3759 feet) as seen from the southwest across the southeastern arm of Blue Mountain lake. Photo by E. E. Kellogg, Blue Mountain Lake, N. Y.

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Photo by Dewitt Allen, Potsdam, N. Y.
View southwestward across Long lake from a point about a mile northeast of Long Lake village. Owl's Head mountain lies just to the left and Clear pond just to the right of the middle background.

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Plate 3



Photo by G. B. Wells, Blue Mountain Lake, N. Y.

View southwestward across Blue Mountain lake from Merwin's Hotel. Eagle and Utowana lakes are just visible in the distance.

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of this sort in the Adirondacks. One of these extends across the quadrangle from the vicinity of Pine lake westward to Blue Mountain and Utowana lakes, and the other across the northern side of the quadrangle.

Raquette river, a tributary of the St Lawrence, is the largest north-flowing stream out of the Adirondack region. Blue Mountain lake drains westward through Raquette lake into Raquette river and into Long lake which latter is merely an enlargement of the river itself. Two prominent northeast-flowing tributaries of the upper Hudson river (Cedar river and Indian river) cross the southeastern portion of the quadrangle, Cedar river having some 15 or 16 miles of its course, and Indian river only 2 or 3 miles of its course, within the map limits. Rock river, the largest feeder of Cedar river within the area, has its source in the hills south of Blue Mountain lake and flows eastward nearly across the quadrangle, Rock lake being only an enlargement of the river. The Chain lakes, which are partly within the map limits, drain southward into Rock river about a mile above its mouth. In all, more than fifty ponds and lakes, or parts of lakes, lie within the quadrangle.

Excepting the glacial and postglacial deposits, all the rock formations of the quadrangle are of Precambrian age. Given in the regular geologic order they are as follows:

Glacial and postglacial deposits: Till, moraines, erratics, kames, lake deposits, etc.

Diabase: Two or three small dikes; nonmetamorphosed.

Pegmatite: Frequently found cutting nearly all types of the older rocks, including the gabbro; nonmetamorphosed.

Gabbro: Occasionally occurring as dikes or small stocks; more or less gneissoid; intrusive into the older rocks.

Syenite and granite: These are the most widespread rocks of the region with many facies from a basic or gabbroic phase of the syenite to typical granite and granite porphyry; distinctly gneissoid; intrusive into the Grenville and anorthosite.

Anorthosite: Two small masses only which are separated from the great area lying mostly in Essex county; more or less gneissoid; intrusive into the Grenville.

Grenville series: Prominently developed only in the southern half of the quadrangle; thoroughly crystalline stratified rocks, including various gneisses, limestones, and quartzite.

Some normal faults are present but they are far less prominent than in the eastern and southeastern Adirondack region.

Published statements dealing directly with the geologic features of the quadrangle are very scant, consisting of only a few paragraphs altogether. The following list includes the principal papers containing references to the quadrangle itself or the Adirondack region in general:

1839-41. **Emmons, E.** Geological Reports on the Second District of New York. 1839, p. 224-30; 1841, p. 113-33. These are the earliest published statements on the geology of Hamilton county.

1842. **Emmons, E.** Geology of New York, pt 2, on the Geology of the Second District, p. 414-17.

1897. **Kemp, J. F. & Newland, D. H.** Preliminary Report on the Geology of Washington, Warren, and Parts of Essex and Hamilton Counties. 17th Annual Rep't N. Y. State Geologist, p. 551-53.

1898. **Kemp, J. F., Newland, D. H., & Hill, B. F.** Preliminary Report on the Geology of Hamilton, Warren, and Washington Counties. 18th Annual Rep't N. Y. State Geologist, p. 156-57.

1905. **Cushing, H. P.** Geology of the Northern Adirondack Region. N. Y. State Mus. Bul. 95. A valuable treatise on Adirondack geology in general.

1907. **Cushing, H. P.** Geology of the Long Lake Quadrangle. N. Y. State Mus. Bul. 115. A detailed account of the geology of the region immediately north of the Blue Mountain quadrangle.

1912. **Miller, W. J.** Early Paleozoic Physiography of the Southern Adirondacks. N. Y. State Mus. Bul. 164, p. 80-94. Presents evidence to show that the central Adirondack area was not submerged during the Paleozoic era.

1913. **Miller, W. J.** The Geological History of New York State. N. Y. State Mus. Bul. 168. A book on the geology of the State with many references to the Adirondack region, particularly in chapter 3.

1914. **Miller, W. J.** Magmatic Differentiation and Assimilation in the Adirondack Region. Geol. Soc. Amer. Bul., 25:243-64. Discusses the origin and age relations of the various facies of Adirondack syenite and granite.

1916. **Miller, W. J.** Origin of Foliation in the Precambrian Rocks of Northern New York. Jour. Geology, 24:587-620.

PRECAMBRIAN ROCKS

Grenville Series

General character. The Grenville rocks of the Adirondack region, so far as our present knowledge is concerned, are to be

classed with the oldest known formation in the crust of the earth. They are very largely, at least, stratified rocks, the original sediments such as limestones, sandstones and shales having been thoroughly metamorphosed into crystalline limestones, quartzites, and various schists and gneisses. Since the foliation and stratification planes are always coincident, it seems quite certain that the Grenville strata have never been subjected to very severe lateral compression, at least not sufficiently great ever to have obliterated the bedding surfaces. As judged by the character, great thickness and areal extent not only throughout the Adirondack region but also through much of eastern Canada, we may safely conclude that the Grenville beds were deposited under marine waters much as were the sediments of later geologic periods. Concerning the character and location of the lands from which the sediments were derived and the sea floor upon which they were deposited, we are at present ignorant. It is certain that the Grenville rocks are many millions of years old.

Areal distribution. Approximately 26 square miles of Grenville rocks are separately represented on the accompanying geologic map of the Blue Mountain quadrangle. There must also be added some 10 or 12 square miles more represented in the mixed gneiss areas and also inclusions mapped and unmapped in the igneous rocks. Thus about one-sixth of the area of the quadrangle is occupied by Grenville strata. On the Newcomb sheet the writer has seen large areas of Grenville; Cushing has mapped considerable areas on the Long Lake sheet; and the writer has seen many Grenville outcrops on the Tupper Lake sheet along the road from Long Lake to Long Lake West. Our knowledge is therefore sufficient to make it positive that the Grenville is prominently represented in the midst of the Adirondack region. Accordingly, certain older views implying very slight development of the Grenville there must be abandoned.

Within the quadrangle no attempt has been made to map the different facies of the Grenville separately because the heavy drift accumulations and consequent scarcity of exposures in certain portions of the Grenville valleys render any satisfactory areal subdivisions impossible. To a very considerable extent the crystalline limestone with its closely associated hornblende and pyroxene gneisses might be separately mapped, but it has seemed best to allow the known extent of the limestone areas to be brought out by indicating the actually observed outcrops of that rock upon the geologic map.

An important Grenville area, nearly 4 miles wide from north to south across the valley at Indian Lake village, extends without an interruption up the Cedar river valley for 11 miles with a width usually from one-quarter to 1 mile. The most abundant rock of this area appears to be coarse, crystalline, graphitic limestone with closely associated hornblende and pyroxene gneisses. Exceptions are 1 to 1½ miles north and northwest of Indian Lake village where the rock is largely a white feldspar-quartz gneiss.

Another prominent Grenville belt extends from Pine lake without a break through the valley of Rock river to Thirty-four marsh and thence into the basin of Blue Mountain lake. Its widest places are in the vicinity of Rock lake (nearly 2 miles) and in the Blue Mountain lake basin (nearly 1½ miles). The basin of Blue Mountain lake is largely occupied by Grenville limestone, many ledges being visible both above and below the water level. Within this belt the only other limestone exposures were observed on Rock river about a mile below the outlet of Rock lake. In the vicinity of Thirty-four marsh, gray Grenville gneisses only were seen. Quartzite and gray gneisses are prominent in the ridge just north of Pine lake, while on Cedar river, between one-half and 1 mile above the mouth of Rock river, white feldspar-quartz gneiss together with quartzite, hornblende gneiss and gray banded gneisses are prominently developed. Northwest of Rock lake heavy drift rather effectually conceals the Grenville.

As shown on the geologic map, the two belts of Grenville just described — one along Cedar river and the other along Rock river — are certainly connected through the valley south of Rock lake, but only a few exposures of hornblende and hornblende-garnet gneisses and white gneisses could be found on account of the heavy drift in this valley.

The small area extending northeastward from Unknown pond contains several exposures of Grenville limestone and it apparently consists mostly of this rock and associated hornblende gneiss.

The prominent depression crossing the line from the Blue Mountain to the Newcomb sheet and containing the Chain lakes (except the first and second), Mud, Deer, and Jackson ponds, is certainly almost entirely occupied by Grenville limestone and its associated hornblende gneiss.

Where the road to Newcomb crosses the Essex county line, a small area of Grenville shows various quartzitic and pyroxenic gneisses in comparatively thin layers. This is really only the west-

ward extension of the large Grenville area in the vicinity of Newcomb.

In the extreme northeastern corner of the map an area of less than a square mile shows few outcrops, these being chiefly of hornblende gneiss.

The inclusions large enough to be separately mapped north of Sprague pond, 2 miles south-southwest of Sprague pond, west of Grassy pond, west of Minnow pond, and west of Buck mountain consist of hornblende gneiss. The small mass on the side of Stephens pond consists of white feldspar and pyroxene gneiss with some limestone. The small area on the road 1 mile west of Fishing brook crossing in contact with, and more or less shot through by, pink granite consists of hornblende gneiss and nearly white feldspar-quartz gneiss containing some pyrite and pink garnets.

Three small areas of Grenville within the mixed gneisses are respectively on the eastern shore of Long lake one-third of a mile south of the northern map limit; on the western shore of the lake directly opposite the last named area; and on the western shore of Long lake a little south of west of Long Lake village. The first two areas named show large exposures of white sillimanite gneiss and gray gneisses containing red garnets and pyrite, while the second named area shows large outcrops of a greenish gray almost syenitic looking gneiss with specks of pyrite.

Description of Grenville types. For purposes of comparison with other areas with the idea of possibly working out certain of the broader structural and stratigraphic relations of the Grenville series in the Adirondack region, the more important types of Grenville of the quadrangle are here described somewhat in detail.

Crystalline limestone. The southern half of the quadrangle, in common with the Newcomb, the southern half of the Schroon Lake, the North Creek, and the Thirteenth Lake quadrangles, shows rather extensive development of Grenville limestone, decidedly more so in fact than the southeastern, southern, and southwestern border portions of the Adirondacks. Throughout all the area just mentioned much of the limestone is very similar, being thoroughly crystalline, very calcitic, usually graphitic, mostly closely associated with hornblende, hornblende-garnet or pyroxene gneisses, and of great thickness — several thousand feet at least.

Sometimes the limestone ledges scarcely show stratification, but usually the original bedding surfaces are marked by layers in which the dark minerals are more abundant (see plate 4). Because of

its plasticity under pressure, the limestone is generally much folded or twisted so that dips and strikes are very variable.

As already stated, the actually observed limestone outcrops are indicated upon the accompanying geologic map.

Perhaps the most abundant variety of limestone is medium to moderately coarse grained, nearly white, with irregular quartz grains in varying amount up to 20 per cent, scattering flakes of graphite (often with perfect hexagonal outlines) up to 4 or 5 mm across, and sometimes tiny specks of pyrrhotite. Many big exposures of such rock occur along Cedar river within 2 miles of where it enters the quadrangle; in the vicinity of Indian Lake village, and in and around Blue Mountain lake.

Another variety is much like the above except for numerous grains or small crystals of pale to dark green pyroxene (coccoilite) scattered through the rock. The pyroxene is often more or less serpentinized.

Still other variations are due to absence of quartz or graphite from either of these varieties.

Irregular shaped masses of pyroxene or hornblende gneiss have sometimes been forced into the relatively plastic limestone under pressure (see plate 4).

Hornblende-garnet gneisses. Rocks of this kind are frequently found in contact (or interbedded) with the limestone. The most common facies is a fine to medium-grained, dark-gray gneiss consisting of about equal parts of hornblende and feldspar and in which are embedded scattering red garnets (almandite) up to three-quarters of an inch across. Among the readily accessible exposures are: one-half of a mile east of Indian Lake village; $1\frac{1}{2}$ miles south-east of Forest House; and on the island one-quarter of a mile northwest of Blue Mountain Lake village (no. 21, table 1).

A less common facies is somewhat similar to the above but has some biotite and the scattering, rounded, red garnets (almandite) up to 5 or 6 inches in diameter which are completely inclosed within envelops of black hornblende crystals. This type of garnet gneiss is exactly like that recently described by the writer as occurring at the garnet mine on Gore mountain near North Creek.¹ Good outcrops may be seen $2\frac{1}{2}$ miles south-southeast of Forest House in a small mine prospect. Better exposures occur in the old garnet

¹ Econ. Geol. Magazine, 7:5, 1912, p. 493-501. Also N. Y. State Mus. Bul. 164, 1913, p. 95-103.

Plate 4



Photo by W. J. Miller, 1914

A ledge of Grenville limestone on Cedar river, one-half mile northeast of the main road bridge across the river. Stratification of the limestone is well shown as well as the rounded masses (dark colored) of Grenville pyroxene gneiss which have been kneaded into the relatively plastic limestone under pressure.

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Plate 5



Photo by W. J. Miller, 1914

Falls at the head of the gorge on Cedar river due east of Waterbarrell mountain. The rock is Grenville limestone.

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mine one-half of a mile east of Bullhead pond on the adjoining Newcomb sheet.

Hornblende-feldspar gneiss. These gneisses are also very commonly found in contact (or interbedded) with the limestone. They are to be distinguished from the hornblende-feldspar-garnet gneisses above described chiefly by the absence of garnet. One facies is medium grained and nearly black with only 10 to 20 per cent of feldspar. Sometimes this gneiss, within an inch of a limestone contact, is full of tiny red garnets, the lime for their development apparently having been furnished by the adjacent limestone during the process of metamorphism.

Another variety is fine to medium grained and contains perhaps 30 to 40 per cent of feldspar together with a few per cent of biotite.

These hornblende-feldspar gneisses are nearly always found where there are extensive exposures of limestone.

Pyroxene gneisses. So far as could be determined, these gneisses also mostly appear to be closely associated with the limestone either clearly interbedded with them or distributed in irregular shaped masses in them, having been broken up and forced into the relatively plastic limestone under pressure (see plate 4).

A common variety of the pyroxene gneisses is fine to medium grained and greenish gray, consisting largely of bright green pyroxene (coccilite), quartz and feldspar with numerous tiny red garnets and some titanite through the mass. Sometimes a crude banded appearance is due to a concentration of the pyroxene in layers parallel to the foliation. Excellent exposures occur 1 mile south-southwest of Indian Lake village in the mixed gneiss area (nos. 6 and 11, table 1).

A rock very similar to this, but with numerous graphite flakes instead of garnet, outcrops along the river just east of Waterbarrel mountain.

Another variety consisting mostly of green pyroxene (coccilite) with some quartz and a little feldspar is very frequently closely involved with the limestone. Excellent outcrops occur along the road near the county line 9 miles east of Long Lake village, and near the eastern end of the largest island in Blue Mountain lake (no. 22, table 1).

Quartzites. As compared with the mapped areas of the southern and southeastern Adirondacks, quartzites are not so prominently developed in the Grenville of the Blue Mountain quadrangle. Also they vary greatly in composition, scarcely any two localities showing

Table 1 — Thin-sections of Grenville rocks

Slide no.	Field no.	Orthoclase	Microperthite	Microcline	Plagioclase	Quartz	Monoclinic pyroxene	Hornblende	Biotite	Tremolite	Garnet	Magnetite	Calcite	Pyrite	Apatite	Zircon	Zoisite	Titanite	Muscovite	Graphite	Hematite
6...	21 2(a)	....	15	3	Al. 10	43	15	....	....	....	10	....	1 1/2	little	1 1/2	....	....	....	....	....	....
7...	2d 3	10	50	15	....	20	....	....	....	....	4	....	....	....	....	....	....	....	....	....	....
11...	21 1	....	20	20	....	35	....	....	....	....	2	....	2 1/2	....	....	....	....	....	....	....	....
19...	54 2	40	....	....	Ol.-An. 35	23	little	....	....	....	1 1/2	....	....	....	....	....	....	....	....	....	....
20...	7m 5	....	52	5	Al.-Ol. 15	22	....	....	....	....	5	....	....	....	....	....	....	....	....	....	....
21...	8d 11	....	....	....	Lab. 37	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
22...	8c 7	....	....	....	Ol. 2	15	72	50	16	....	....	....	....	....	....	....	....	....	....	....	....
23...	8d 10	....	26	....	Ol.-An. 1	40	....	....	....	....	16	....	10	....	....	....	....	....	....	....	....
26...	8c 19(b)	17	20	....	Ol.-An. 2	20	40	....	....	....	20	....	....	....	....	....	....	....	....	....	....
43...	15d 10	....	48	5	Ol. 10	35	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
51...	16m 2(b)	....	....	....	....	40	5	....	....	....	....	....	....	....	....	....	....	....	....	....	....
53...	16j 1	....	29	29	....	40	....	....	....	54	....	....	....	....	....	....	....	....	....	....	....

No. 6, 1 1/4 miles south-southeast of Indian Lake village (from a mixed gneiss area) ; no. 7, on Cedar river 1 1/2 miles north-east of Waterbarrel mountain ; no. 11, 1 mile south-southwest of Indian Lake village (from a mixed gneiss area) ; no. 19, top of mountain 1 mile southwest of Unknown pond ; no. 20, on Cedar river one-half of a mile southwest of Pine lake ; no. 21, on island one-half of a mile northwest of Blue Mountain Lake village ; no. 22, eastern end of largest island in Blue Mountain lake ; no. 23, small island just southeast of next to the largest island in Blue Mountain lake ; no. 26, small island one-fifth of a mile southeast of largest island in Blue Mountain lake ; no. 43, 1 mile southwest of Long Lake village ; no. 51, main road one-third of a mile east of Essex County line ; no. 53, on the road 6 miles west of Long Lake village.



View in the gorge of Cedar river due east of Waterbarrell mountain. The white rock is Grenville limestone and the overlying gray rock is Grenville hornblende gneiss. A small thrust fault shows in the distance.

Photo by W. J. Miller, 1914

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the same kind of rock. Most of the quartzites are fine to medium grained and thin bedded. In general there are two important varieties — one with feldspar and the other without.

The feldspathic quartzites carry from 10 to 25 per cent of feldspar together with 5 to 15 per cent of either biotite, muscovite or green pyroxene, or slight amounts of tiny red garnets or graphite flakes.

The nonfeldspathic varieties contain 90 or more per cent of quartz together with either biotite or muscovite.

Among the better quartzite exposures are the following: on several islands in the northern part of Blue Mountain lake; in the ridge just north of Pine lake; and along the road at the county line 9 miles east of Long Lake village.

Feldspar-quartz-biotite-garnet gneisses. These gneisses are not very abundant and vary greatly. Perhaps the most common variety is a fine to medium-grained, crudely banded, light-gray rock made up mostly of feldspar and quartz in addition to 10 or 15 per cent of biotite and varying amounts of pale pink garnets.

Good exposures may be seen respectively three-quarters of a mile and $1\frac{1}{2}$ miles east of Blue Mountain Lake village on the road; on the small island just southeast of next to the largest island in Blue Mountain lake (no. 23, table 1); and on the ridge just north of Pine lake.

Feldspar-quartz gneisses. These light-gray to white gneisses are represented in considerable amount.

The most common variety is medium grained and made up very largely of feldspar and quartz with scattering red or pink garnets and almost no dark minerals. In exceptional cases grains of pyrrhotite or pyrite, or flakes of graphite, occur. Rocks of this sort are extensively exposed from 1 to $1\frac{1}{2}$ miles northwest and north of Indian Lake village. Other good outcrops occur on Cedar river one-half to three-quarters of a mile southwest of Pine lake (no. 20, table 1); on Cedar river $1\frac{1}{2}$ miles northeast of Waterbarrel mountain; and on the road respectively 6 miles (no. 53, table 1) and 9 miles (at the map edge) east of Long Lake village.

Apparently these gneisses are the same as certain white gneisses recently described by the writer as occurring within the Lake Pleasant¹ and the North Creek² quadrangles. That these are not eruptive rocks is quite certainly proved by their interstratification with definitely known Grenville strata and by their content of

¹ N. Y. State Mus. Bul. 182, p. 11. 1915.

² N. Y. State Mus. Bul. 170, p. 13. 1914.

graphite at some localities, for example, on Cedar river from one-half to three-quarters of a mile southwest of Pine lake. This matter is of considerable importance because these rocks so closely resemble certain white gneisses recently described from the Saratoga quadrangle by Cushing and by him rather thought to be ancient granites belonging with the so-called "Laurentian granite."¹

Another variety of the feldspar-quartz gneisses is light gray, medium grained, very homogeneous and rather syenitic looking. This rock contains specks of pyrite and weathers brown. When first encountered it was thought to be a special facies of the syenite, but later the same sort of rock was found interbedded with true Grenville gneiss. Good outcrops may be seen in the small Grenville area 1 mile southwest of Long Lake village (no. 43, table 1); in the small Grenville area 2 miles northeast of Long Lake village; and on Cedar river respectively $1\frac{1}{2}$ (no. 7, table 1) and $3\frac{1}{2}$ miles northeast of Waterbarrel mountain.

Sillimanite gneisses. These are also light gray to white gneisses but are rare, having been found at only two places. A big ledge, 100 feet across within the small Grenville area 2 miles northeast of Long Lake village, consists of fine to medium-grained, banded, feldspar-quartz gneiss with some layers very rich in glistening needles of sillimanite.

The top of the mountain ridge (mixed gneiss) just southwest of Unknown pond shows sillimanite and garnet gneisses all shot through by granite. The sillimanite gneiss is a mass of fine-grained feldspar through which are scattered delicate, glistening needles of sillimanite in great abundance.

Tremolite gneiss. At the map edge on the Long Lake-Newcomb road, tremolite gneiss is interstratified with thin-bedded quartz-feldspar gneiss and dark pyroxene gneiss. The composition of this rock is shown by no. 51, table 1.

Feldspar-graphite gneiss. On the largest of the three small islands just southeast of the largest (Long) island in Blue Mountain lake, there are good exposures of gray to brown, medium-grained, thin-bedded, feldspar-graphite gneiss, the graphite being disseminated through the rock as numerous tiny flakes (no. 26, table 1).

Anorthosite-gabbro

Two small areas of anorthosite-gabbro are shown on the geologic map respectively $1\frac{1}{4}$ miles northeast and $1\frac{1}{2}$ miles north of the

¹ N. Y. State Mus. Bul. 169, p. 21-26. 1914.

Long Lake bridge. In spite of considerable variations in the character of these rocks, they are distinctly different from any other rocks observed within the quadrangle. In every essential respect they appear to be like the anorthosite-gabbro border facies and small outlying masses of the great anorthosite body within the Long Lake quadrangle as described by Cushing.¹ Also they are precisely like the border facies of the anorthosite area along the Hudson river (Newcomb sheet) as seen by the writer during the summer of 1914. Therefore it is with some confidence that the two small masses of anorthosite-gabbro within the Blue Mountain quadrangle are regarded as of the same age as the great anorthosite body, being simply outlying masses or off-shoots of the large body similar to those within the Long Lake quadrangle described by Cushing. Identity of age has of course not been established since the two small areas are separated from the main anorthosite body by an interval of nearly 10 miles. According to Cushing the anorthosite (and associated anorthosite-gabbro) is distinctly older than the syenite.

In the area on the eastern shore of the lake the best and most typical exposures are in the immediate vicinity of the southern end of the diabase dike (see map) on the point which there extends into the lake.² This whole point is practically a solid exposure. Within 30 or 40 feet of the dike the anorthosite-gabbro best shows its variable character. It is mostly light gray to nearly white, medium to very coarse grained and largely devoid of gneissic structure. One patch of the rock is almost pure labradorite feldspar with fresh, bluish gray, rounded cores up to 1 or 2 inches across clearly showing the twining bands and embedded in a finer grained granular matrix of white plagioclase. These cores clearly represent the portions of the original large labradorite crystals which were uncrushed during the process of metamorphism. Most of the rock, however, is medium to, only moderately coarse grained with fewer and smaller uncrushed labradorite cores, some andesine, a considerable percentage of dark minerals (chiefly hornblende, pyrite and magnetite), and some red garnets. Very locally the dark minerals may reach 30 to 40 per cent, when the rock is dark gray and distinctly gneissoid. The gneissoid structure becomes fainter with diminution of dark minerals, much of the rock not showing it at all. Some of the rock close to the contact with the diabase dike

¹ N. Y. State Mus. Bul. 115, p. 473-76. 1907.

² This anorthosite-gabbro, at the water's edge, contains a small inclusion of typical Grenville limestone.

is very light gray and more compact looking, the feldspar having a dull instead of the usual shiny luster. In thin section (no. 66, table 2) the feldspar and hornblende appear to be badly decomposed. Possibly this facies is an effect of the heat of intrusion of the diabase dike. About 50 feet east of the dike the anorthosite-gabbro has the same mineral composition (no. 64, table 2) but is considerably weathered to brownish gray, shows very few, small, uncrushed feldspar cores, and is moderately gneissoid. From 75 to 90 feet east of the dike the rock is weathered to a deep brown, is clearly gneissoid and looks so much like a basic phase of the syenite that, seen alone, it would scarcely be regarded as belonging with anorthosite (no. 65, table 2). All the facies just described grade perfectly from one into the other, but farther eastward, that is beyond 100 feet from the dike, there are no exposures at the base of the mountain so that the relation of the anorthosite to the syenite of the mountain could not be determined. Along the lake shore for one-quarter of a mile northward from the rocky point just described there are ledges of gray anorthosite-gabbro. Then, after a short interval, there is a ledge of what is taken to be a basic (gabbroic) phase of the syenite (no. 55, table 4). A few rods directly south of the rocky point there is a ledge of either gabbroic anorthosite or a basic phase of syenite, probably the latter (no. 56, table 4). Still farther south along the lake shore, there are outcrops of basic facies of the syenite. Thus, although the evidence is not conclusive, the anorthosite-gabbro appears to grade into a basic phase of the syenite of the region. Similar gradations have been quite definitely proved within the Long Lake quadrangle by Cushing who suggests that "the observed relations seem to point to the conclusion that the change is due to actual digestion, by the molten syenite, of material from the adjacent (anorthosite) gabbro."¹

In the small anorthosite-gabbro area west of the lake, big outcrops cover fully one-half of an acre. The rock is much like the main bulk of the anorthosite-gabbro just described as occurring on the eastern shore of the lake. Toward the interior the mass is entirely devoid of foliation, is light gray, shows occasional uncrushed, bluish-gray labradorite crystal cores up to one-half or three-quarters of an inch across, and contains a considerable percentage of dark-colored minerals and some garnet. Otherwise much of the rock is darker gray and moderately gneissoid to almost black

¹ N. Y. State Mus. Bul. 115, p. 479. 1907.

and highly gneissoid. Within this anorthosite-gabbro there are several inclusions of light gray Grenville gneiss up to 2 or 3 feet wide, some bands of amphibolite and a few masses (one 25 feet across) of granitic syenite, all of these being arranged approximately parallel to the foliation of the inclosing rock where that structure is present. Whether the granitic syenite occurs as inclusions or as dike-like intrusions could not be positively determined, though they are most likely the latter.

Table 2 — Thin-sections of anorthosite — gabbro

SLIDE NUMBER	Field no.	Plagioclase	Hornblende	Diallage	Enstatite	Augite	Magnetite	Quartz	Garnet	Apatite	Zoisite	Zircon	Pyrite	Biotite	Chlorite
61.....	17e 5(c)	an.-Lab. 63	35	...	...	...	1	...	...	little	little	little	...	...	...
62.....	17e 5(d)	an.-Lab. 88	1	9	...	...	1	...	...	little	little	little	...	little	...
63.....	17e 5(e)	an.-Lab. 70	11	15	...	...	3	...	...	...	...	...	...	...	...
64.....	17e 5(f)	an.-Lab. 77	15	...	...	...	3	...	4	...	...	...	...	...	...
65.....	17e 5(g)	an.-Lab. 80	16	...	...	little	1	...	...	...	...	...	...	...	...
66.....	17e 5(h)	an.-Lab. 80	...	...	...	...	1	...	...	...	...	...	...	2	...
58.....	17e 9	ol.-Lab. 66	6	...	2	2	1½	12	10	...	little	little	...	...	19

Nos. 61 to 66 inclusive are from the area on the eastern shore of Long lake; no. 58 is from the area west of Long lake and is more acidic than the usual rock there.

A number of small pegmatite dikes cut through the whole mass of rock. There are no exposures of any kind immediately surrounding the anorthosite-gabbro area so that nothing could be learned regarding its relation to the other rocks of the vicinity.

Syenite and Its Facies

The syenite and its basic and acidic facies are the most widespread of all the rocks. As here considered they vary greatly, ranging from what may be termed a normal quartz syenite to a basic (dioritic to gabbroic) facies on one hand to granitic syenite and granite on the other. Since these facies grade back and forth into one another, sharp boundary lines between them do not exist and their separation on the geologic map depends to a considerable extent upon personal judgment based upon some years of experience with the rock types and checked up by the study of numerous thin sections.

As is now well known, the syenite is younger than the Grenville series and distinctly intruded into it, there often being dike-like

tongues of syenite cutting the Grenville and clearly defined inclusions of Grenville in the syenite. According to the work of Cushing on the Long Lake quadrangle, the syenite is also younger than, and intrusive into, the anorthosite.¹ For most part at least, the granites of the Blue Mountain quadrangle are only differentiation phases of the great syenite body and of practically the same age as the syenite, though the possible presence of some unproved granite either distinctly older or younger than the syenite must be admitted. This matter is more fully discussed in connection with the granite. Both the gabbro stocks or dikes and the diabase dikes are certainly younger than the syenite.

Normal quartz syenite. More than one-third of the area of the quadrangle is occupied by the normal syenite, it being widely distributed in exceedingly irregular bodies.

As usual throughout the Adirondacks, the normal or most typical syenite is dark greenish gray when fresh and weathers to a light brown, though apparently fresh pinkish or reddish syenites do occur rather locally. The depth of weathering usually varies from a fraction of an inch to several inches or, more locally, to a foot or more. In general the amount of weathered rock here seems to be greater than in the border regions of the Adirondacks, doubtless due to the fact that the central region was neither so long nor so vigorously glaciated. Immediate surfaces of syenite ledges are sometimes light gray to almost white, probably due to the leaching out of iron compounds by water rich in decomposing organic matter. A case in point is the big, bare ledge which looks like a snow bank in midsummer well up on the side of Blue mountain and clearly visible from the south for some miles. A hand specimen from this ledge shows a thin, white surface layer under which is a brown zone an inch thick and which in turn merges downward into the greenish gray fresh rock.

As regards granularity, the normal syenite is mostly medium grained; that is, the crystals range in length from 1 to 5 mm. Sometimes, however, it is finer grained while again it becomes moderately coarse to even slightly porphyritic. More or less granulation of the rock is a very common feature, the feldspars showing the greatest effect of the crushing of the mineral grains.

All the rock is foliated, most of it moderately so. At times the foliation is very faint, while at other times it is excessively developed, especially along shear zones where the rock may have an almost schistose appearance.

¹ N. Y. State Mus. Bul. 115, p. 479-82. 1907.

The normal syenite always contains quartz, the average amount being 12 to 20 per cent in the slides examined, and when it is greater than 20 per cent the rock is no longer regarded as normal, but rather granitic syenite to granite. Microperthite almost invariably makes up from one-third to two-thirds of the rock. Orthoclase is much less constantly present in variable amounts. Plagioclase (albite to andesine) never fails in amounts up to 35 per cent. When the rock is relatively rich in plagioclase it is a monzonite, though here, for convenience, classed with the normal syenite. Common hornblende with yellowish green to dark green pleochroism usually occurs in variable quantities up to 25 per cent, while green monoclinic pyroxene (usually diallage) frequently makes up 2 to 20 per cent of the rock. Enstatite was observed in only one slide. Both hornblende and pyroxene sometimes occur in the same rock. Magnetite (ilmenite), apatite and zircon in small quantities rarely fail. Biotite, garnet, zoisite and titanite are more sporadically present in small amounts.

The following table will serve to show the mineralogical variations of thin sections from carefully selected specimens of the normal syenite.

Table 3 — Thin-sections of normal quartz syenite

Slide Number	Field no.	Orthoclase	Microperthite	Microcline	Plagioclase	Hornblende	Biotite	Augite	Enstatite	Diallage	Magnetite	Quartz	Garnet	Apatite	Zircon	Zoisite	Hematite	Titanite
3.....	10 9	8	45	.....	Ol-An. 20	10	.....	.....	.....	.....	1 1/2	15	.....	little	little	.....	.....	.....
4.....	11 4	.....	07	.....	Ol. 10	5	.....	.....	.....	.....	1	15	.....	.....	little	.....	.....	.....
9.....	2d 4	.....	35	.....	Ab-Ol. 10	.....	.....	.....	.....	.....	.....	14	.....	.....	.....	.....	.....	.....
13.....	3e 4	25	30	10	Ab-Ol. 7	8	1	.....	.....	.....	little	18	.....	.....	.....	little	.....	.....
14.....	3a 4	13	52	.....	Ab-Ol. 12	7	.....	.....	.....	.....	.....	15	.....	.....	.....	.....	.....	.....
31.....	9e 8	63	.....	.....	Ol-An. 10	1	.....	5	.....	.....	little	20	.....	.....	.....	.....	.....	.....
34.....	10b 1	.....	72	.....	Ol-An. 4	3	2	.....	.....	.....	.....	15	2	.....	.....	.....	.....	.....
41.....	15d 3(a)	.....	59	.....	Ol. 20	.....	.....	.....	10	.....	1 1/2	18	.....	.....	.....	.....	.....	.....
49.....	10e 7	.....	52	.....	Ol. 18	9	.....	.....	.....	.....	2	18	.....	.....	.....	.....	.....	.....
38.....	14m 6	.....	27	8	Ol. 15	25	3	.....	.....	.....	3	18	.....	.....	.....	.....	.....	.....
45.....	10e 16	.....	48	.....	Ol. 35	.....	.....	.....	.....	3	1	12	.....	.....	.....	.....	.....	.....
46.....	10e 9	.....	42	.....	Ol. 35	3	.....	.....	.....	3	1	15	.....	.....	.....	.....	.....	.....

Nos. 38, 45 and 46, though practically monzonites, are for convenience classed with the syenite. No. 3, on Cedar river northeast of Waterbarrel mountain; no. 4, main road near map edge west of Indian lake; no. 9, Cedar river 1½ miles north-east of Waterbarrel mountain; no. 13, Cedar river 2 miles south of Stephens pond; no. 14, summit of Blue ridge at map edge; no. 31, close to Blue mountain trail at altitude 2400 feet; no. 34, 1½ miles west of west end of Minnow pond; no. 41, road 1½ miles southwest of Long Lake village; no. 49, eastern shore of Long lake one-quarter of a mile northeast of the bridge; no. 38, map edge 1⅓ miles south of the road to Newcomb; no. 45, one-quarter of a mile southeast of Long Lake bridge; no. 46, one-half of a mile northeast of Long Lake bridge.

Basic (dioritic to gabbroic) facies of the syenite. The rocks included under this caption really have the composition of diorite or gabbro though they have been quite certainly produced either by pure differentiation of the syenite magma or by the assimilation of country rock through which the syenite magma was intruded. They are quite different in aspect from the typical later gabbros which are separately represented on the geologic map in that they show neither the diabasic texture nor the peculiar mottled appearance of these later gabbros. In fact the color, texture and structural features are essentially the same as those of the normal quartz syenite already described.

Mineralogically, the basic facies of the syenite differ from the normal syenite chiefly by absence of microperthite, reduced amount or absence of orthoclase and quartz, and predominance of plagioclase (oligoclase to andesine).

The following tabular summary illustrates the mineralogical composition of typical thin sections from several areas of the so-called basic syenite.

Table 4—Thin-sections of basic (dioritic to gabbroic) phases of the syenite

Slide no.	Field no.	Orthoclase	Plagioclase	Hornblende	Hypersthene	Diallage	Biotite	Garnet	Magnetite	Quartz	Pyrite	Zircon	Apatite	Zoisite
2....	1h 6	23	Ol.-An. 35	....	....	....	15	10	1	15	....	↓	↓	.....
36....	12b 1	....	Ol.-An. 33	25	12	8	....	8	1	12	....	little	little	little
44....	15b 3	8	Ol.-An. 26	35	20	5	....	....	4	....	1↓	little	little	.....
55....	17f 9	....	Ol.-An. 70	1	25	....	....	....	3	....	↓	little	little	little
56....	17e 4	....	Ol.-An. 42	35	....	....	....	15	1↓	6	....	little	little	little

No. 2, 2½ miles south-southeast of Sprague pond; no. 36, Buttermilk falls on Raquette river; no. 44, eastern base of Owl's Head mountain; no. 55, eastern shore of Long lake 1½ miles northeast of the Long Lake bridge; no. 56, eastern shore of Long lake 1⅛ miles northeast of the Long Lake bridge.

The rock in the small area near the middle southern border of the quadrangle (no. 2, table 4) is pale greenish gray, medium grained, clearly gneissoid, with occasional crystals of biotite and red garnet set in a granular mass of feldspar. This rock appears to grade into the surrounding normal syenite.

In the area including Buttermilk falls there are many outcrops, the best being at the falls where, in a great ledge, the rock (no. 36, table 4) is mostly rather homogeneous, greenish gray when fresh,

though somewhat darker than the normal syenite on account of a larger percentage of dark minerals, moderately gneissoid, and with some small garnets. At times there are streaks of dark, basic gneiss (presumably Grenville) more or less fused in, giving the rock something of a wavy or contorted aspect and suggesting the possibility that the basic syenite here has been produced by assimilation of such dark gneiss by the syenite magma. Ledges on the low mountain ridge to the east and southeast of the falls are very similar.

The rock of the Owl's Head mountain area (no. 44, table 4) is dark, greenish gray when fresh and weathers to a deep brown. It is very homogeneous, medium grained, clearly gneissoid, and usually rather rich in dark minerals though without garnets. The darker portions have a decided gabbroic look though not like the later gabbros of the quadrangle. Occasionally a small phenocryst of plagioclase stands out in the medium-grained, granulated matrix.

The area northeast of Long Lake village borders the anorthosite-gabbro and seems to form a transition between that rock and the normal syenite, though such a transition is not positively demonstrable as above discussed in connection with the anorthosite-gabbro. Exposures occur only close to the lake either side of the anorthosite-gabbro, the rock (nos. 55 and 56, table 4) being fine to moderately coarse grained, greenish gray weathering to brown, clearly gneissoid and fairly rich in dark minerals. Sometimes there is a suggestion of a porphyritic texture. A few bands of amphibolite parallel to the foliation occur in the rock along the lake shore south of the anorthosite-gabbro.

The Triplet Hill mass is probably only a westward extension, under the lake, of the area last described, the rock being very similar though at the summit of the hill some of the rock is rather distinctly porphyritic.

A very small body of basic syenite shown on the map northeast of Long Lake village is only a wide band parallel to the foliation of the syenite and not sharply separated from it. The rock is of decided igneous aspect, rather hornblendic and with occasional garnets up to more than an inch across. Apparently this rock has been produced by the assimilation of some Grenville hornblende-garnet gneiss by the syenite magma. The rock bears a very close resemblance to a definitely proved assimilation product of this sort at the garnet mine on Gore mountain near North Creek in Warren county.

Granitic syenite. The granitic syenite is really only an acidic phase of the syenite in which the quartz content lies approximately



Buttermilk falls on Raquette river, two miles southwest of Grove (Deerland). The rock is a typical basic facies of the syenite. A broken rock zone due to faulting shows just to the left of the middle of the falls.

Photo by W. J. Miller, 1914

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between 20 and 25 per cent. So far as could be determined in the field, this granitic syenite is intermediate between the normal syenite and the granite, always grading into one or the other or both. Nothing like definite evidence was obtained to show that any one of these rock types cuts another. Though any attempt separately to delimit the granitic syenite on the geologic map must be rather arbitrary, it is believed that, as a result of careful attention to the matter in the field and the study of thin sections, the areal relation of the granitic syenite to the normal syenite and the granite are fairly well brought out.

This granitic syenite occupies nearly one-third of the area of the quadrangle and, like the normal syenite, is widely distributed in very irregular shaped bodies.

Much of the rock shows the usual color of the normal syenite, but pinkish to reddish granitic syenite is not uncommon, thus suggesting the typical granite into which it grades.

Texturally and structurally the granitic syenite shows essentially the same sorts of variations as the normal syenite.

Mineralogically the granitic syenite differs from the normal syenite chiefly in the larger content of quartz, somewhat smaller content of plagioclase, and absence of pyroxene.

In table 5 the compositions of a number of thin sections of granitic syenite are shown.

Granite

About 15 square miles of the quadrangle are separately mapped as granite, but, since this rock is abundantly represented in most of the mixed gneiss areas, the actual extent must be increased to something like 25 square miles. No field evidence was found to show that any of the granite is distinctly older or younger than the syenite or granitic syenite, though in many places perfect gradations from one to another were observed.

The granite facies vary in color from light gray or greenish gray to pinkish gray or light red. In some cases the reddish color is a mere surface weathering effect as, for instance, on the eastern face of Waterbarrel mountain where, within 1 or 2 feet, a superficial pink color passes downward into a light brown, and finally into a greenish gray color where the rock is very fresh. In other cases the reddish color permeates the rock to depths of 10 or 20 feet as is well exhibited in the quarry on the road $2\frac{1}{2}$ miles east of Long Lake village. In still other places the pinkish or reddish color seems to be the inherent color of the rock or, if due to

Table 5 — Thin sections of granitic syenite and granite

	Slide no.	Field no.	Orthoclase	Microcline	Microperthite	Plagioclase	Quartz	Hornblende	Biotite	Magnetite	Hematite	Pyrite	Zircon	Apatite	Zoisite	Titanite
Granitic Syenite	18	5m 3	15	.....	40	Ol. 10	22	8	3	1	.....	little	little	little	.....	.....
	20	5e 5	.....	.....	54	Ol. 10	24	8	.....	1	.....	.....	little	.....	.....	.....
	30	of 4	.....	.....	55	Ol. 8	22	4	.....	1	.....	.....	little	.....	.....	.....
	33	10d 8	.....	10	54	Ol. 8	25	1	.....	1	.....	.....	little	.....	.....	.....
	35	12d 3	.....	.....	50	Ol. 12	25	4	2	1	.....	.....	little	.....	.....	.....
	39	12d 7	.....	.....	50	Ol. 13	25	11	.....	1	.....	.....	little	.....	.....	.....
	40	14e 1	.....	.....	47	Ol. 10	24	15	.....	1	.....	.....	little	.....	.....	.....
	41	17c 3	.....	.....	56	Ol. 5	24	10	1	1	.....	.....	little	.....	.....	.....
	57	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
																
Granite	5	1c 2	.....	18	25	Ol. 2	50	4	.....	.....	.....	.....	little	little	.....	.....
	16	4g 9	.....	.....	30	Ol.-An. 5	30	.....	.....	.....	.....	.....	little	little	.....	.....
	37	12g 5	25	.....	48	Ol. 12	28	9	.....	.....	.....	.....	little	.....	.....	.....
	42	15d 3(b)	.....	8	40	Ol. 10	35	9	.....	1	.....	.....	little	.....	.....	.....
	48	16k 1	.....	5	32	Ol. 20	26	6	.....	.....	.....	.....	little	.....	.....	.....
	50	16h (a)	.....	25	27	Ol. 10	28	5	.....	2	.....	.....	little	.....	.....	.....
	54	17b 1	.....	.....	50	Ol. 10	30	6	3	.....	.....	.....	little	little	.....	.....
																
																
																

No. 18, 2½ miles north-northeast of Indian Lake village; no. 20, 1 mile north-northeast of Blue Mountain Lake village; no. 30, summit of Blue mountain; no. 33, one-half of a mile south of Mud pond; no. 35, 2 miles southeast of Grove (Deerland); no. 39, 1 mile northeast of Grove (Deerland); no. 40, summit of Mt Sabattis; no. 57, on road 1½ miles due west of Triplet hill (from mixed gneiss area); no. 5, eastern face of Water-barrel mountain; no. 16, summit of mountain one-half of a mile north of Sprague pond; no. 37, one-half of a mile northwest of Salmon pond; no. 42, road 1½ miles southwest of Long Lake village (from local band in syenite); no. 48, stone quarry on road 2 miles west of eastern map limit; no. 50, road close to gabbro stock 3½ miles east of Long Lake village; no. 54, northeastern shore of Clear pond.

weathering, the color change has affected the apparently fresh rock to depths beyond the zone of observation.

As regards texture and degree of foliated structure, the facies of granite show practically the same kinds of variations as the normal syenite already described.

Mineralogically, the granite differs from the facies of the syenite chiefly in the higher quartz content and more common occurrence of microcline. Table 5 includes examples of the more common variations of granite from different parts of the quadrangle.

Various types of light to dark-gray Grenville gneisses occasionally occur as distinct inclusions in the granite, but limestone inclusions were never noted. Where such inclusions are of sufficient abundance to make up a considerable percentage of the mass, the rock has been classed with the mixed gneisses (see below). The inclusions are nearly always flattened and drawn out parallel to the foliation of the granite almost exactly as in the case of the syenite and granitic syenite. Also, as in the mixed gneisses below described, many of the inclusions are sharply separated from the inclosing rock, while others grade into the granite as a result of partial fusion.

Long, narrow, amphibolite (presumably Grenville) inclusions, apparently like those so characteristic of the so-called "Laurentian granite" of the Thousand Islands region, also occur in some parts of the granite, but are not abundant. Perhaps the best observed locality for such inclusions is on the north shore of Clear pond where numerous streaks or narrow layers of amphibolite are drawn out parallel to the foliation of the pink granite and sometimes in sharp contact with it. Such amphibolite inclusions are, however, by no means characteristic of the granite since they are about as commonly present in the facies of the syenite. Thus the normal syenite and its basic variation on either shore of Long lake north-east of Long Lake village afford excellent exhibitions of amphibolite inclusions of the kind just described. The nature and frequency of the inclusions therefore afford no criterion by which any possible age differences between the syenite and granite could be determined.

The absence of distinct limestone inclusions from the granite harmonizes with the Thousand Islands region as described by Cushing and Smyth¹ and the Haliburton-Bancroft area of eastern Canada as described by Adams and Barlow.² According to Adams, the lenses

¹ N. Y. State Mus. Bul. 145, p. 37. 1910.

² Canada: Department of Mines, Geol. Survey, Memoir 6, p. 62-114.

of limestone caught up by the granite or syenite magma were converted into amphibolite.

Still another feature of interest is the occasional occurrence of rapid transitions from syenitic to granitic material and vice versa, giving rise to a kind of banded structure parallel to the foliation but with the bands not at all sharply separated from each other. A case in point is the freshly blasted ledge on the road $1\frac{1}{2}$ miles southwest of Long Lake village where a band of light-gray hornblende granite (no. 42, table 5) $2\frac{1}{2}$ feet wide passes by insensible gradations on either side into a greenish gray pyroxene syenite (no. 41, table 3). Such phenomena appear to be rather common in the Adirondack region, many observations having been made in the various quadrangles studied by the writer, and also in the Long Lake and Elizabethtown-Port Henry quadrangles by Cushing and Kemp respectively. For most part these banded structures are believed to be a result of magmatic differentiation, but in some cases it is probable that lenslike inclusions of Grenville rocks have been more or less assimilated by the inclosing syenite or granite.

Granite Porphyry

Many times the pink or gray granites have suggestions of porphyritic texture, though there is but one small area of typical granite porphyry which could be mapped as such. This is in marked contrast with the relative prominence of such porphyry within the Broadalbin, North Creek and Lake Pleasant quadrangles mapped by the writer in the southeastern Adirondack region.

The small area of granite porphyry occupies about one-quarter of a square mile in the vicinity of the Indian lake dam. Some of the rock has been used in the construction of the dam. There are many good exposures, the best being at the dam and in the quarries just east. Where fresh the rock is greenish gray, and where weathered it is pinkish. The rock is always coarse grained and rather gneissoid with the porphyritic texture usually well developed though at times only poorly so. The feldspar phenocrysts are always highly granulated. Locally biotitic shear zones occur. At times some small Grenville gneiss inclusions may be seen.

A thin section of the typical rock from near the dam shows the following mineral percentages: orthoclase 10; microcline 25; microperthite 15; oligoclase to andesine 4; quartz 40; hornblende 2; biotite 1; garnet 2; apatite $\frac{1}{2}$; and a little zircon and magnetite.

Plate 8



Photo by W. J. Miller, 1914

The State dam at the end of Indian lake. All of the rock is granite porphyry. A vertical fault surface is visible at the end of the footbridge.

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Mixed Gneisses

General statements. Under this caption are included chiefly Grenville rocks which are cut to pieces by, and more or less closely involved with, various facies of the syenite-granite body. Sometimes the Grenville, and sometimes the igneous, rocks prevail. Of the igneous rocks in most of the areas, granite appears to predominate. In general it may be said that these mixed gneisses include: long, narrow masses of Grenville and syenite or granite distinctly recognizable as such but showing rapid alterations at right angles to the strike of the foliation; bodies of syenite or granite containing numerous sharply defined lenslike inclusions of Grenville; Grenville rocks intimately shot through by igneous rocks after the fashion of so-called "lit-par-lit" injection; bodies of syenite or granite containing a multitude of small, lenslike Grenville inclusions whose borders commonly grade into the inclosing rock so that the Grenville is often difficult to recognize as such; rocks which are intermediate in character between the Grenville and igneous rocks and which have clearly been produced by magmatic assimilation; and still other rocks of variable types and puzzling character whose origins are admittedly rather uncertain. The small scale of the map, together with the usual lack of sufficient outcrops has, for most part, rendered inadvisable any attempt to map separately very small masses of Grenville or igneous rocks recognizable as such within these mixed gneiss areas. It is not uncommon to find small exposures with a so-called "mixed gneiss" aspect within the great syenite-granite intrusive body, but here too it would be unsatisfactory to attempt any consistent separate delimitation of such rocks.

Area south to southwest of Indian Lake village. This area of about $2\frac{1}{2}$ square miles shows many features characteristic of a typical mixed gneiss area.

Along the river and in the fields east of Indian lake dam, there are numerous outcrops of granite and Grenville rocks (even including limestone) which are clearly recognizable as such, while certain other outcrops consist of more or less intimately associated granite and Grenville rocks where the distinctive characters are not so evident.

Very instructive exposures occur along the road 1 mile a little west of south of Indian Lake village. Going southward the first outcrop beyond the pink granite is well-banded pyroxene (cocco-lite), Grenville gneiss, most of which contains considerable feldspar

and quartz together with some calcite and tiny brown garnets and a little titanite (no. 11, table 1). There are occasional nests, up to 8 inches in diameter, of pure bright-green pyroxene (cocolite). Some of the layers of Grenville are pyroxene quartzite. The next ledge on the road, a few yards to the south, contains Grenville gneisses exactly like those just described, but which are all shot through by pinkish granite with more or less assimilation of the Grenville by the granite. Sometimes Grenville streaks are fairly distinct, and sometimes they clearly fade into the granite which latter rock then contains a sprinkling of small crystals of green pyroxene and has a composition really much more like granitic syenite to normal quartz syenite, though quite different in outward appearance. A thin section of this changed rock shows the following mineral percentages: orthoclase 18; microcline 24; microperthite 25; oligoclase to andesine 5; quartz 21; pyroxene (cocolite) 6; and less than 1 per cent each of magnetite, titanite, zircon and muscovite. It is certain that the pyroxene of this granitic syenite has somehow been derived from the Grenville gneiss, the evidence rather clearly pointing to actual absorption or assimilation of some of the Grenville by the granite.

Area between Indian Lake village and Rock lake. In this area of some 3 square miles, the most interesting exposures are on the mountain lying southwest of Unknown pond. For about a mile the top of the fire-swept mountain is an almost continuous, barren rock-ledge in which a certain type of the mixed gneisses is beautifully exhibited. Pink, medium-grained, biotite granite is all shot through Grenville white gneiss and Grenville light-gray, feldspar-quartz-garnet gneiss, these gneisses usually occurring in wavy, disconnected, thin layers throughout the granite. It is evident that there has been no considerable assimilation, though usually the gneiss boundaries are not sharply defined against the granite. Farther down, on the south face of this mountain, fairly large masses of dark, rusty-looking, Grenville gneisses occur in the granite.

Along the road directly west of the mountain just described, there are closely associated gray granite and gray Grenville gneisses.

The mountain directly south of Unknown pond consists mostly of pink granite with numerous streaks or bands (sometimes 10 to 20 feet wide) of Grenville hornblende gneiss.

Area south of Blue Mountain lake. This area of about 9 square miles, extending from Blue Mountain lake southward to the base of

Blue ridge, is in most respects very typical of central and southern Adirondack mixed gneisses. Throughout the area various types of Grenville strata have been more or less cut to pieces by pink granite or granitic syenite, the dips generally being very steep and the igneous masses having nearly always penetrated the Grenville parallel to the foliation. More rapid wearing away of the weaker Grenville belts accounts for the arrangement of low ridges approximately parallel to the foliation. Many exposures show either pure Grenville or pure granite, while in many others the granite and Grenville are more or less intimately associated, in some cases local assimilation having taken place. Excellent outcrops in the open field between Blue Mountain Lake village and Crystal lake afford a practical demonstration of the very intimate relations of granitic and Grenville gneisses with some intermediate rocks due to magmatic assimilation. The granites are pinkish to grayish and rather variable though always gneissoid. In certain outcrops gray, biotite or dark garnet or pyroxene, Grenville gneisses may be seen to grade into the igneous rock with no visible contacts. In a few cases the contacts are fairly sharp. Most of the exposures, however, consist of rocks of distinctly intermediate character which are clearly the products of local assimilation.

Area south to southwest of Grove (Deerland). This body of mixed gneisses, covering about 2 square miles, mostly comprises outcrops of gray to pinkish granitic to syenitic gneisses filled with streaks or inclusions of dark to light-gray gneisses (presumably Grenville), the rocks being crudely banded, very gneissoid, and often considerably contorted.

Exceptional exposures occur as big ledges in the bed of the stream which is the outlet of South pond. The rock, instead of being distinctly gneissoid to banded, is streaked or wavy as though small amounts of dark Grenville had been partially fused and assimilated by syenite magma, the syenitic character being preserved in spite of the inclusions. The whole presents what might be termed a "marble-cake" appearance.

Area across the northern portion of the quadrangle. This area of about 12 square miles extends completely across the northern portion of the quadrangle and is apparently the southern border of the so-called "Long Lake gneiss" as mapped by Cushing in the region immediately to the north. For most part the rocks of this area are rather typical mixed gneisses, that is, they are largely granite or syenite more or less intimately associated with Grenville,

these latter being chiefly dark hornblende gneisses and light-gray quartz-feldspar gneisses arranged as bands, belts, or lenslike inclusions in the igneous rocks and parallel to the foliation. In some cases these belts or inclusions of Grenville merge into the inclosing igneous rocks because of melting of their borders at the time of the magmatic invasion. Though the outcrops are rather poor in many portions of the area, it seems fairly certain that the granitic and syenitic rocks predominate.

A solid ledge for 200 yards in the gorge of Fishing brook just east of the county line shows a preponderance of pink granite which contains distinct belts of both dark and light Grenville gneisses parallel to the foliation.

Where the secondary roads diverge two-thirds of a mile west of the Long lake bridge, there are fine ledges of rather variable rock consisting in part of syenitic and gray granitic gneisses with distinct amphibolite and gray Grenville gneiss bands parallel to the foliation. Much of the rock, however, is streaked to almost thin-banded due to injection of the gneisses by thin layers of magma (see plate 9). At one place a very small mass of Grenville limestone was noted.

On the shores of Long lake within one-half of a mile of the northern map edge, there are fine exhibitions of typical mixed gneisses. Thus on the eastern shore one-eighth of a mile southwest of the small mapped Grenville mass, there is a big ledge of syenitic to almost gabbroic looking gneiss with streaks, blotches and bands of dark, biotite-garnet and gray, biotite-quartz gneisses arranged parallel to the foliation. The southern portion of this ledge is pink granite which merges (as a result of fusion) into a biotite-quartzite.

The end of the sharp point projecting into the lake less than one-quarter of a mile southwest of the locality last described is a solid ledge of mixed gneisses which looks as though Grenville strata had been thoroughly cut up, and more or less fused, by the syenite magma so that both Grenville and syenite often do not show their typical features.

In certain other ledges on the lake shores there is good evidence for some fusion of Grenville strata, and frequently bands of amphibolite up to 20 or 30 feet wide occur parallel to the foliation of the syenitic or granitic gneisses.

Other areas. In the bed of Rock river nearly 1 mile below the outlet of Rock lake, large exposures show green pyroxene, white

Plate 9

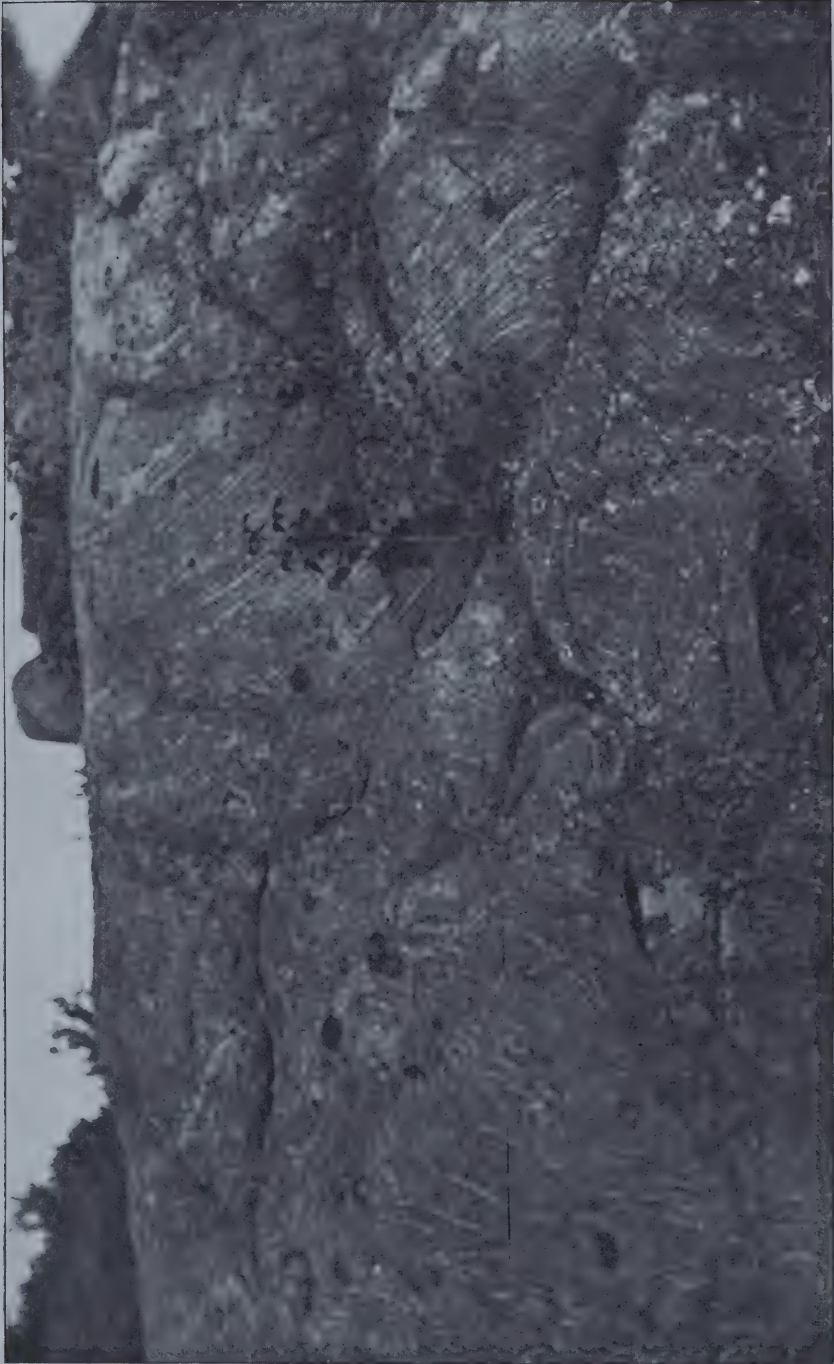


Photo by W. J. Miller, 1914
A ledge of mixed gneisses, two-thirds of the Long Lake bridge. The rock is streaked to thin-banded due to injection of the gray Grenville gneiss by thin layers (light colored) of granitic material but without notable assimilation.

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Plate 10



Photo by W. J. Miller, 1914

A ledge of Grenville and granite mixed gneisses, two-thirds of a mile west of the Long Lake bridge and similar to that shown in plate 9, but with two veins of pure white quartz parallel to the foliation on the left and a dike of pegmatite at the lower right. The pegmatite sharply cuts both the gneiss and one of the quartz veins, the latter not being shown in the picture. The camera was pointed downward to get the picture.

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granitic-looking and hornblende gneisses cut by masses of granitic syenite and pink granite.

The small body of mixed gneisses exposed along the river southwest of Sprague pond shows not only normal syenite and Gr nville hornblende gneiss, but also a basic, igneous-looking gneiss apparently an assimilation product.

The other small areas mapped as mixed gneisses require no special description. It is of course to be remembered that small exposures showing the so-called "mixed gneiss" aspect are occasionally met with in many parts of the quadrangle.

Gabbro Stocks and Dikes

Thirteen gabbro stocks or dikes have been discovered and separately represented on the accompanying geologic map. They are rather widely distributed over the quadrangle, though eight of them are confined to its southern one-fourth. That these gabbro masses are younger than any facies of the great intrusives already described is clearly proved by their sharp contacts against those intrusives. In many respects these gabbros are similar to those of the North Creek quadrangle recently described somewhat in detail by the writer,¹ but they do not present so many variations. Most of them at least have rounded to elliptical ground plans and practically vertical contacts with the country rock, so that they are of the nature of stocks, but in some cases where the exposures are not very satisfactory, they may exist as dike-like forms. As a rule, the long axes of the exposed gabbro bodies are almost, or quite, parallel to the foliation of the country rock. No branching of any gabbro mass was noted. The observed variations in size of the areas is from a single small exposure a few rods across to others from one-half to three-fourths of a mile long.

A feature of particular interest is the almost invariable association of pegmatite dikes or veins with the gabbros, the former cutting the latter. The same thing has been noted in connection with the gabbro stocks of the North Creek and Lake Pleasant quadrangles, but its significance is scarcely known.

Megascopically, the gabbros are seen to be medium to moderately coarse grained and dark gray when fresh with roughly equal amounts of feldspar and dark minerals, the latter including hornblende or pyroxene or both, biotite, ilmenite and usually tiny reddish garnets scattered through the rock. On weathering, the gabbros

¹ N. Y. State Mus. Bul. 170, p. 26-38. 1914.

assume a deep-brown color. The larger and more typical stocks commonly have a nonmetamorphosed interior facies which has a more or less well-developed diabasic texture, and a border facies (often amphibolite) which is so thoroughly gneissoid that the diabasic texture has disappeared. The typical nonmetamorphosed gabbros, with diabasic texture and large percentage of black minerals, is readily distinguished from all other rocks of the region. Some of the border facies, however, are either amphibolites which look much like certain dark gneiss inclusions commonly seen in the granite and syenite, or dark gneisses which might be easily confused with certain basic facies of the syenite.

Under the microscope the mineralogical composition of the gabbros is shown by the following examples taken from various stocks or dikes.

Table 6—Thin sections of typical gabbros

Slide no.	Field no.	Plagioclase	Hornblende	Hypersthene	Diallage	Biotite	Magnetite	Pyrite	Garnet	Apatite
8.....	2c 1	Ol.-Lab. 20	35	40	.....	1	1	.....	3	.....
15.....	4g 1	An.-Lab. 28	20	15	10	2	little	little	25	.....
17.....	4m 15	Lab. 34	15	15	17	2	2	.....	15	.....
25.....	8c 19(a)	An.-Lab. 55	20	15	4	5	little	.....	1	.....
27.....	8c 8	An.-Lab. 55	25	15	1	1	3	.....	.....	little
52.....	16i 8	Lab.-An. 55	.....	20	.....	5	8	.....	12	.....

No. 8, 1 mile north of Waterbarrel mountain; no. 15, one-third of a mile west-southwest of Sprague pond; no. 17, 1½ miles north-northeast of Indian Lake village; no. 25, small island one-quarter of a mile southeast of the largest island in Blue Mountain lake; no. 27, largest island in Blue Mountain lake; no. 52, eastern side of stock 4 miles east of Long Lake village.

The largest gabbro stock, 4 miles east of Long Lake village, is very typical (no. 52, table 6) and has numerous outcrops with the amphibolite border facies well exhibited along the road.

On the largest island in Blue Mountain lake the gabbro (no. 27, table 6) is not so typical, its interior being somewhat gneissoid, medium grained and with only slightly developed diabasic texture, while its border facies is finer grained, more granulated, and amphibolitelike. Very similar rock (no. 25, table 6) outcrops on the small island just to the southeast and it is probable that these two masses are parts of the same gabbro stock now mostly covered by water. If they are connected, the submerged portion may be nonmetamorphosed and with better diabasic texture.

The large stock north of Waterbarrel mountain shows some big ledges of medium to coarse-grained rock with perfect diabasic texture, and feldspar laths up to three-quarters of an inch long (no. 8, table 6). Some amphibolite occurs, especially on the north side of the stock, but much of the gabbro is very gneissoid, this being true in places (particularly toward the east) of even the coarsest grained rock, the feldspars having been highly granulated, the diabasic texture destroyed and occasional garnets developed. This very coarse-grained, gneissoid gabbro so greatly resembles a large mass somewhat doubtfully called gabbro along the West Branch of the Sacandaga river in the Lake Pleasant quadrangle¹ that this latter rock is now quite confidently regarded as a metamorphosed coarse gabbro. Apparently it is a facies of gabbro not often met with.

The other gabbro masses of the quadrangle are quite typical, in every way and require no special description.

Pegmatite

Pegmatite dikes or veins were occasionally met with in many parts of the quadrangle. One type occurs as narrow masses of moderately coarse grain with long axes essentially parallel to the foliation of, and not very sharply separated from, the inclosing syenite or granite. Dikes of this sort were, no doubt, injected practically contemporaneously with the great intrusives, possibly as a late phase of the intrusions.

Another type of pegmatite, clearly later in origin, is generally very coarse grained, cuts through rocks of all ages except the diabase, shows very sharp boundaries and usually cuts across the foliation of the country rock. Dikes of this sort are wholly devoid of metamorphism. They range in width from 1 or 2 inches to 100 feet and in length up to 200 yards or more. A few of the most conspicuous observed examples are as follows: coarse-grained dike 10 or 15 feet wide cutting Grenville hornblende gneiss on Cedar river $3\frac{1}{2}$ miles west of Indian Lake village; a 15 foot wide dike some 40 or 50 feet long cutting Grenville limestone just southeast of the small gabbro stock 1 mile north-northeast of Indian Lake village; small but very sharply defined dikes cutting the basic syenite at the summit of Owl's Head mountain; a dike fully 100 feet wide and 200 yards long at the western border of the gabbro on the largest island in Blue Mountain lake; small dikes cutting syenite near the western end of Long Lake bridge; small dikes cutting mixed

¹ N. Y. State Mus. Bul 182, p. 29. 1916.

gneisses two-thirds of a mile west of Long Lake bridge; a number of small dikes cutting the anorthosite-gabbro west of Long lake; and several small dikes cutting the large gabbro stock $1\frac{1}{2}$ miles north-northeast of Indian Lake village.

Veins of pure white quartz a few inches wide sometimes occur in the syenite, granite or mixed gneisses and apparently always parallel to the foliation. On top of Owl's Head mountain and also two-thirds of a mile west of Long Lake bridge, sharply defined pegmatite dikes a few inches wide were observed to cut such quartz veins (see plate 10). Within the North Creek quadrangle the writer has found diabase cutting pegmatite of the kind here described. So far as the evidence goes, therefore, this type of pegmatite is intermediate in age between the gabbro and the diabase.

Graphite in pegmatite. A feature of particular interest in connection with the pegmatites is the content of graphite in two small dikes cutting Grenville limestone respectively one-half and three-fifths of a mile northwest and north of the bridge across Cedar river. In addition to some large flakes of graphite, these dikes contain numerous balls or globular masses of graphite from 1 to 5 mm in diameter. They look exactly like tarnished lead shot. They occur either as inclusions in feldspar or along contacts between feldspar and quartz. When broken open these graphite balls are seen to possess a perfectly developed radiated structure.

Diabase Dikes

Only two small diabase dikes were located within the quadrangle. It is quite possible, if not probable, that others exist but were not encountered in the rough and heavily glaciated region, though no boulders were anywhere found which would lead to the suspicion of the presence of other dikes. So far as the positive evidence goes for this and the adjoining Long Lake quadrangle, diabase dikes are notably smaller and rarer in the central than in the eastern and southeastern Adirondacks. The finer grained, to sometimes even glassy, texture of the diabase proves it to be the youngest of the Adirondack intrusives.

The larger dike cuts the anorthosite gabbro on the shore of Long lake a little over a mile northeast of the bridge. The best exposures are on the point already described as showing the most typical anorthosite-gabbro. Here the dike is considerably branched but shows a maximum width of 57 feet including two or three bands or inclusions of the country rock. Sharp contacts against the

anorthosite-gabbro are visible across the whole rock ledge, the country rock (in places) at the contacts plainly showing the effects of the heat of intrusion. Toward the interior of the mass the diabase exhibits an excellent diabase texture, white feldspar laths up to one-quarter of an inch long standing out in a finer grained, dark, bluish gray ground mass. A thin section from the interior of the dike shows the following mineral percentages: labradorite 44; augite (pale reddish brown) 18; biotite 8; chlorite 18; magnetite (or ilmenite) 11; and pyrite 1. Due to more rapid chilling, the dike borders are very fine grained to even glassy. About 100 yards northeast at the lake edge, this dike again outcrops. It here also shows branches, the greatest visible width being 27 feet. The dike strikes south 40° west.

The other dike also lies on the shore of Long lake and less than one-half of a mile northeast of the bridge. Its main body is exposed for 35 feet with strike south 40° west and a width up to 6 feet, though one wall only is shown. A very small tongue branches off this portion. It is fairly evident that this dike formerly extended at least 200 feet farther northward but has been eroded away along the shore leaving the vertical wall of the country rock distinct. What appears to be a separate dike here 6 inches to 1 foot wide and 30 to 40 feet long is quite certainly only a branch of the larger one now eroded away toward the north. This branch dike is distinctly brecciated due to faulting. In thin section the rock from the 6 foot wide dike shows practically the same mineral composition as the larger one farther northward already described.

The perfect alignment of the strikes of these two dikes suggests the possibility that they are really portions of a single intrusive which is largely concealed under the lake, but of course they may be entirely separate. Also the fact that these dikes lie in or close to, and parallel to, the zone of fracture (fault) which has determined the position of the Long lake depression, would suggest that the diabase was intruded along this fault zone but, if so, there was renewed faulting in the same zone because one of the dikes is brecciated.

ROCK STRUCTURES

Foliation

Except the diabase and certain pegmatites, all the Precambrian rocks of the quadrangle show more or less foliation. As a rule, the gabbro masses are devoid of foliation except around the borders

where they are usually amphibolitic. The members of the syenite-granite series are mostly distinctly gneissoid, though at times they are only very faintly so. A striking feature is the frequent rapid change within a few rods from rocks which are very clearly gneissoid to others in which foliation is scarcely visible. The Grenville strata, as usual in the Adirondacks, always show perfect parallelism of stratification and foliation, these rocks invariably being thoroughly crystalline.

Of the many strike and dip observations made in the field, the better ones, so distributed as to show the principal variations, have been selected and plotted on the accompanying geologic map. In a general way nearly east-west strikes greatly prevail, with southerly dips most common in the north and northerly dips most common in the south. To be more exact, the northwestern half of the quadrangle, or all lying north of a line passing from the northern base of Blue ridge to the eastern base of Fishing Brook mountain, shows very few exceptions to a nearly east-west strike and southerly dip, the amount of the dip generally being from 60 to 80 degrees; while the southern half of the quadrangle, or all south of the line above indicated, exhibits more variations but with an average nearly east-west strike and prevailing northerly dip generally from 25 to 50 degrees.

A noteworthy feature is the occasional local occurrence of strikes making high angles with the general trend of the foliation of the quadrangle. An example of this in syenite is in the mountain mass lying just east of Tirrell pond (see map). Such a sharp change in strike is more in harmony with the idea that the foliation of the syenite and granite was produced as a kind of flow structure during the process of intrusion rather than by a great force of compression because, if due wholly or even largely to compression, the foliated structure must everywhere have developed essentially at right angles to the direction of the compressive force.

Exceptional strikes are of most common occurrence in the Grenville limestones and in the mixed gneisses, these being readily explained by the fact that such rock masses were most subject to being twisted and disturbed at the time of the great igneous intrusions.

A most interesting arrangement of strikes and dips occurs along the southern side of the quadrangle within a strip 2 or 3 miles wide. Thus, within the eastern portion of this strip the strikes are mostly northwest-southeast, with dips to the northeast; toward the middle

the strikes are nearly east-west, with northerly dips; and within the western portion of the strip the strikes are northeast-southwest, with dips to the northwest. The dips seem to radiate from a center not far south of the middle of the southern boundary of the map or apparently from the great Panther-Snowy mountain mass of the Indian Lake sheet. A series of flattened elliptical curves drawn from the center just mentioned would approximately parallel the strikes as shown on the southern side of the Blue Mountain quadrangle. It would be interesting to know how the strikes and dips run across the northern few miles of the Indian Lake quadrangle. The significance of this symmetric arrangement of strikes and dips is not precisely known, though the presence of the belt of Grenville some distance out (along Cedar river) with strike practically parallel to the curving strike of the igneous rock may imply something. This belt of Grenville on the east is known to continue from the vicinity of Indian Lake village across the southeastern corner of the Newcomb sheet and for at least several miles southward on the Thirteenth Lake sheet. On the west this same Grenville belt quite certainly continues southward for some miles through the Cedar river valley in the northwestern part of the Indian Lake sheet. Thus the great Panther-Snowy mountain mass of igneous rock is known to be completely bounded on the west, north and northeast by this belt of Grenville strata whose strikes and dips show it to lap upon the flanks of the great igneous mass. The writer is inclined to believe that we have here a large scale radial development of strikes and dips produced in the syenite as a kind of flow structure when the magma was being intruded, and if we consider the Grenville to have been more or less raised or domed over the surface of the invading magma, this readily accounts for the existing circumferential belt of Grenville whose dips show it to lap upon the flanks of the syenite, the general cover of Grenville having been removed from the dome by erosion. In other words, we here appear to be dealing with something of the nature of a laccolithic intrusion.

Folds

The general change from southerly dips in the northern portion of the quadrangle to northerly dips in the southern portion may possibly indicate a great synclinal fold in the foliation with axis passing from the northern base of Blue Ridge through Dun Brook mountain. This may, however, be interpreted simply as due to differences in flowage of the great masses of intruding magma.

Very local twisted or contorted structures within the Grenville limestones and associated pyroxene and hornblende gneisses, and also within portions of the mixed gneisses, are frequently met, but practically nothing like distinct folds could be determined within the Grenville formation, or rather such fragments of the formation as now remain. There is no evidence that the Grenville strata were ever thrown into folds as a result of any great compressive or mountain-making force brought to bear upon the region, the present strikes and dips probably, for most part at least, having been due to tilting and upturning of the strata as a result of the great igneous intrusions.

Faults

General considerations. In marked contrast with the eastern and southeastern Adirondack regions, recognizable faults are few in number and their topographic influence relatively minor. Of the five faults represented on the accompanying geologic map, four strike northeast-southwest or parallel to the predominating fracture lines of the Adirondacks. All five of the faults might more properly be called zones of fracture or crushed zones which are nearly straight for considerable distances. In no case was the whole displacement found to follow a sharply defined fault-surface, but rather there are broken-rock zones from 25 or 30 to 100 or more feet wide in which fault breccias, slickensided surfaces, and local fault surfaces are frequently seen.

Referring to apparently similar phenomena on the Long Lake sheet, Professor Cushing says: "Lines of excessive faulting are not infrequent in the eruptives. In such places from two to four joint sets are well marked, and the joints are closely spaced, their distance apart being measured in inches rather than feet, chopping up the rock into a multitude of small blocks, and forming prominent lines of weakness in it. Often multiple faulting has taken place along these strips on one of the joint sets, grinding and slickensiding the rock surfaces."¹ The longest shattered-rock zone of this kind mentioned by Cushing on the Long Lake sheet is in the Raquette falls gorge which is nearly a mile long. Within the Blue Mountain quadrangle, the writer has in several instances observed crushed-rock zones frequently occurring along nearly straight lines for from 2 to 8 miles, and with distinct topographic influence. Such alignments of crushed-rock zones are regarded by the writer as due primarily to faulting, probably multiple faulting. Further-

¹ N. Y. State Mus. Bul. 115, p. 488. 1907.

more, within the quadrangle, finely developed crushed zones have been observed in the Grenville as well as in the eruptives.

Long Lake fault. This fault, with a length of $8\frac{1}{2}$ miles and strike north 30° east, is the longest one within the quadrangle. It has a decided topographic influence, the long, straight, narrow valley now occupied by Long lake having been determined by the crushed-rock zone of weakness. The topography suggests its continuation for at least a few miles into the Raquette Lake quadrangle, and it almost certainly continues the length of Long lake and thence probably along the channel of Calkins brook across a part of the Long Lake sheet. The evidence for the continuation of the fault beyond the limits of the Blue Mountain quadrangle is, however, largely topographic, since but few field observations were made by the writer there.

Passing diagonally across the ledge at Buttermilk falls (plate 7) there is a very distinct crushed-rock zone of considerably decomposed rock 2 or 3 feet wide and traceable for 50 yards with strike north 30° east. Just on the east side of the falls there are two smaller broken-rock zones parallel to the first. Other places where broken-rock zones, with strike north 30° east, may be seen are on the west shore of the lake three-fourths of a mile north of Grove (Deerland); on the shore of the lake just south of the Adirondack Hotel in Long Lake village; on the lake shore nearly one-half of a mile northeast of the eastern end of the bridge across the lake (at the brecciated diabase dike); and on the eastern shore of the lake directly east of Triplet hill where a long ledge shows a broken-rock zone 20 feet wide.

There is no satisfactory evidence for a determination of the up-throw side or amount of displacement of this fault. At present one side of the fault is not notably raised above the other, thus suggesting that any displacement along the fracture zone antedated the development of many of the fault scarps and blocks of the eastern and southeastern Adirondacks. The movements may have taken place even as early as Precambrian time as suggested by Cushing for similar phenomena on the Long Lake sheet.

Cedar river-Squaw brook fault. This fault, with north 30° east strike, extends for over 6 miles across the southeastern corner of the quadrangle, being coincident with the course of Cedar river north of Indian Lake village and continuing southward along Squaw brook of the Indian Lake sheet for fully 6 or 8 miles. Due north of the village, Cedar river follows a remarkably straight course,

mostly in a narrow rock channel, for at least 2 miles, this being due to the fact that the position of the channel there has been determined along the crushed zone of weakness. Along this gorgelike channel wide crushed-rock zones are beautifully developed at many places, one fine example being in the Grenville white gneiss about $1\frac{2}{3}$ miles due north of the village. The continuation of the fault across the valley west of Indian Lake village is not actually demonstrable, the outcrops being scarce with heavy drift covering the apparently critical localities. Its extension along the Squaw brook valley of the Indian Lake sheet is, however, certain as shown by the topography and the presence of crushed-rock zones.

Somewhat higher altitudes immediately on the eastern side of this line of fracture within the adjoining Indian Lake and Newcomb quadrangles, suggest that the upthrow side is on the east, though the difference is not enough to make this at all certain. The prominent scarp northwest of Indian Lake village is due to difference in rock character rather than faulting, the Grenville limestone on the east side having been much more readily worn down than the relatively hard gneisses on the west side. If any movements took place along this line of fracture since the existence of the Cretaceous peneplain, they must have been relatively slight. The principal movements are certainly much older and they may possibly date back to Precambrian time.

Indian Lake fault. This long prominent fault, with northeast-southwest strike, has but 2 miles of its course across the southeastern corner of the quadrangle. The granite porphyry near the western end of the Indian Lake dam is full of shear zones and much of the rock is broken up into a multitude of small blocks. Just at the end of the dam there is a distinct slickensided fault scarp 100 feet long and 15 feet high with some fault breccias. This scarp dips 80° west. There is also a distinct crushed zone parallel to this in the eastern of the two quarries just across the river. No other exposures of the zone of fracture were seen within the quadrangle, but it continues with very prominent topographic influence into both the adjoining Newcomb and Indian Lake sheets. The remarkably straight channels of the Indian and Hudson rivers on the Newcomb sheet are almost certainly developed along a fault which is but a continuation of the Indian Lake fault.

On the Indian Lake sheet this fault has a most decided topographic influence, the long, straight, Indian Lake depression having been determined along the zone of weakness with the Snowy

mountain mass rising very steeply for more than 2000 feet above the lake. The fault divides with one portion following the Miami river valley and the other the long, narrow southern extension of Indian lake, the Mossy Vly brook valley, and thence along the western side of Piseco lake on the Piseco Lake sheet, the southern portion of this line of fracture having already been described by the writer in his report on the Lake Pleasant quadrangle.

From these statements it will be seen that there is a prominent line of fracture, with decided topographic influence, extending from Piseco lake northeastward to near Lake Harris on the Newcomb sheet, or a distance of some 45 or 50 miles. This Indian Lake fault, therefore, ranks as the longest continuous line of fracture yet located in the Adirondack region. This fault is also the only one touching the Blue Mountain quadrangle which gives quite certain evidence regarding the relation of upthrow and downthrow sides. The upthrow side is clearly on the west with the amount of displacement ranging up to 1000 feet or more, as, for example, on the Indian Lake sheet. On the Blue Mountain and Newcomb sheets the amount of displacement is much less. In the vicinity of Indian Lake village the fault has no conspicuous topographic influence because the soft Grenville limestone has there readily been worn down on both sides of the line of fracture.

The generally much greater altitudes on the west side, even in homogeneous igneous rock, shows that important movements have taken place along this fault since the development of the Cretaceous peneplain. Hence this fault is in most respects very similar to many of the prominent ones of the eastern and southeastern Adirondacks.

Other faults. The fault along Cedar river east of Pine lake strikes north 40° east and shows excellent crushed zones but it can not be traced far. On Cedar river, one-half of a mile above the mouth of Rock river, a beautifully developed crushed-rock zone 50 to 75 feet wide is exhibited in the bed and in one wall of the river channel and it can be traced several hundred yards. Absence of any notable topographic influence, except the local determination of the river channel here, suggests that the principal movements along this fault must have antedated the Cretaceous peneplain.

Another line of fracture extends for 2 or 3 miles from the Cedar river valley into the eastern end of the deep valley just south of Blue ridge in the southeastern part of the quadrangle. Crushed-rock zones are well developed with strike north 70° east along the

river and also at several places along the brook in the valley just mentioned. Nothing is known regarding the upthrow side or amount of displacement. It is possible that this fault may extend farther westward through the valley south of Blue ridge.

It is quite possible that other minor zones of fracture occur within the quadrangle but, if so, they are either effectually concealed under heavy drift or escaped detection in the rough, densely wooded country.

Irregular Surface of the Syenite-Granite Intrusive Body

Since the Blue Mountain quadrangle lies in the rugged mountainous district west of that portion of the Adirondacks which is profoundly affected by comparatively recent faulting and contains considerable areas of Grenville strata through which the great intrusions of syenite-granite have taken place, an excellent opportunity is afforded to study the character of the surfaces of the great bathylithic masses.

A glance at the southern half of the accompanying geologic map will reveal the fact that mountains of syenite or granite frequently rise conspicuously above the masses of Grenville. Differences in altitude, often quite abrupt, between syenite or granite and Grenville commonly range from a few hundred to 2000 or more feet. Such marked differences in altitude must be accounted for in either of two ways: (1) by faulting, whereby the Grenville has been relatively dropped down with respect to the igneous masses; or (2) by irregularities on the surfaces of the igneous masses produced during the process of intrusion. That faulting can not be invoked as an explanation in many cases at least is perfectly clear by the fact that direct evidence for faulting is absent from many places where outcrops are good at critical localities, and also by the fact that certain mountain masses of syenite or granite are so nearly surrounded by Grenville strata as to preclude the explanation by faulting. A few concrete examples will serve to prove that the bathylithic surfaces have very notable original irregularities.

Just east and northeast of Rock lake a mountain of granite rises fully 600 feet above the Grenville which latter reaches continuously almost two-thirds of the way around the mountain. Even if we grant the possibility of a fault on one side (though there is not the slightest field evidence for it), we are still forced to conclude that the magma rose at least a few hundred feet above the Grenville now

nearly surrounding the mountain and across its strike. A very similar example is furnished by the mountain south of Rock lake.

The great igneous mass making up Blue mountain rises 2000 feet above the Grenville immediately to its southwest and south. Also the presence of glacial boulders of Grenville limestone and the nature of the topography very strongly suggest that Grenville now is, or formerly was, present in the Tirrell pond valley. No rock exposures occur around the shores of the pond or along its outlet for some distance southward. At any rate, it is clear that much of the great difference in altitude between Blue mountain and the adjacent Grenville must have been caused by the intrusion of the magma through the Grenville.

Perhaps the finest example of marked irregularity of a bathylithic surface is that of the great Panther-Snowy mountain mass occupying the southern portion of the Blue Mountain quadrangle and the northern portion of the Indian Lake quadrangle and already described in detail under "foliation." This large body of syenite, as above explained, apparently rose under and raised up (domelike) the Grenville strata which have all been removed by erosion except the peripheral belt now remaining on the west, north, and northeast. As a result of this intrusion and subsequent removal of Grenville, the higher portions of the syenite mass now rise fully 2000 feet above the Grenville.

A striking illustration of another type of irregularity of bathylithic surface is furnished by the basin (partly on the Blue Mountain and partly on the Newcomb sheet) which contains the Chain lakes (except the first and second lakes), Deer pond, Mud pond, and Jackson pond. The bottom of this basin, which has a length of 4 miles and maximum width of $1\frac{1}{2}$ miles, is wholly occupied by Grenville limestone and its associated hornblende gneiss at an altitude of 1600 to 1700 feet. This valley is completely surrounded by a body of syenite and granite which everywhere rises (usually abruptly) from about 150 to over 800 feet above the valley floor except in the vicinity of the outlet in the southwest. The distinct basinlike character of the depression is clearly brought out on the topographic maps. It is certain that, very largely at least, the differences in altitude between the Grenville and surrounding igneous rocks is due to original irregularities of the surface of the igneous mass produced at the time of the intrusion.

One further point needs emphasis, namely, that the figures above given as representing the amounts of irregularity of bathylithic sur-

faces are in all cases minima, because no account has been taken of the fact of the depth of the existing Grenville below the surface. In many places this depth must amount to some hundreds of feet at least.

GLACIAL AND POSTGLACIAL GEOLOGY

Ice Movement, Depth, and Erosion

Eighteen sets of glacial striae have been observed and plotted upon the accompanying geologic map. Their bearings and distribution are as follows:

1 S 25° W. On the road three-fourths of a mile south of Indian Lake village.

2, 3 S 20° W. On roads respectively 2½ miles south-southeast, and 1¼ miles a little east of south, of Indian Lake village.

4, 5 S 30° W. On the road respectively 3 miles, and 2½ miles, southeast of Forest House.

6 S 45° W. On the road 2 miles east-southeast of Forest House.

7, 8 S 40° W. Near the road at Forest House, and on the road 1½ miles east-southeast of Forest House.

9 S 30° W. On the road 1¼ miles north of Blue Mountain Lake village. Several sets of striae in this vicinity.

10 S 40° W. On the road 1⅓ miles southwest of Deerland (Grove).

11 S 45° W. On the road 1⅓ miles southeast of Deerland (Grove).

12 S 20° W. On the road one-fourth of a mile northeast of Deerland (Grove).

13 S 50° W. Near the Mount Sabattis trail one-half of a mile south of Long Lake village and at an altitude of about 2000 feet.

14 S 40° W. On the branch road to the Sagamore Hotel just southwest of Long Lake village.

15 S 40° W. Close to the lake shore 1½ miles north-northeast of Long Lake village.

16 S 50° W. On the road 1½ miles west-northwest of Long Lake village.

17 S 50° W. On the road nearly 4 miles east of Long Lake village.

18 S 40° W. Near the mountain top (at altitude 2550 feet) 2½ miles west of where the road to Newcomb crosses the county line.

According to this list, it is seen that the extreme range in directions of the glacial striae is from south 20° west to south 50° west,

with an average direction of about south 30° to 40° west. All but three of these sets of striae were found along roads, a reason for this being that unweathered, glaciated rock surfaces are there frequently stripped of drift artificially, thus exposing the glacial marks. This is quite the rule in the Adirondack region.

No striae were noted in the southwestern portion of the quadrangle, nor on the great mountain mass between Mount Sabattis and Dun Brook mountain. The eighteen observed striae are, however, so distributed over the quadrangle as to furnish positive evidence that the general ice current was southwestward across this portion of the Adirondacks. This accords essentially with the observations made by Cushing on the Long Lake quadrangle immediately to the north, and by the writer on the Lake Pleasant quadrangle to the south.

Certain striae, as, for example, those of the Long Lake basin, closely follow the trend of, and may have been influenced by, the topography, though it is quite possible that such parallelism may be largely a coincidence. Other striae are so situated as to demonstrate independence of direction of ice flow and trend of the topography. Examples of such are in the depression between the mountains southeast of Forest House; on the south side (several hundred feet below the top) of the northwestern spur of Blue mountain; and well up on the mountain (altitude 2550 feet) in the northeastern part of the quadrangle.

That the great ice sheet was thick enough to overtop the highest mountains of the region is practically demonstrated by the persistence of the southwesterly ice current in spite of the topography. Actual striae 2550 feet above sea level near the top of the mountain in the northeast and distinctly glaciated ledges (without striae) above 3000 feet on the side of Dun Brook mountain conclusively prove ice currents at such altitudes. Well-worn pebbles and small boulders of Potsdam sandstone derived from the St Lawrence valley were occasionally observed on mountain tops at altitudes of from 2500 to 3500 feet. Again, the great surfaces of comparatively hard and fresh rock on such mountains as Owl's Head, Mount Sabattis, Blue mountain, etc., were quite certainly stripped of rotten rock by the ice and have since been only slightly modified by Postglacial weathering.

The great ice sheet, in its passage across the region, was a sufficiently active agent of erosion to remove most of the Preglacial soils and rotten rock from their original positions. For this reason,

it is quite the rule to find ledges of relatively fresh rock, such ledges frequently being in sharp contact with overlying loose glacial debris. Deeply weathered to even rotten rock is, however, not of very rare occurrence, and the writer believes that such decomposed rock is appreciably more common in this central Adirondack region than, for example, in the southeastern portion. This is quite in harmony with the generally accepted belief that the central Adirondacks were neither so long ice occupied nor subjected to such vigorous ice currents as were the border portions of the mountains.

Rock basins due to ice erosion are not known within the map limits though certain valleys, like those of Long Lake and Blue Mountain lake, may have been deepened by ice erosion, the available data not being sufficient to make any certain decision.

Glacial Deposits

Erratics. Erratics (glacial boulders) are numerous and widely scattered over the quadrangle. As usual they are mostly of very local origin so that, in the absence of sufficient outcrops from certain areas, some idea of the underlying rock formations may be gained by noting the relative numbers of glacial boulders.

Among the erratics which have been derived from ledges wholly without the area under consideration are those of anorthosite and of Potsdam sandstone. Anorthosite boulders, with maximum diameters of 8 or 10 feet, are not very common, they having been most frequently noted in the northern portion of the quadrangle. In view of the fact that the extensive anorthosite body is exposed in great force on the quadrangles immediately to the north and northeast, with the nearest exposures only 5 to 7 miles distant, it is somewhat surprising that fragments of this formation are not more common over the Blue Mountain quadrangle. The combination of shorter time of ice occupancy and less vigorous ice currents over the central Adirondacks than around its borders probably accounts for the relative scarcity of anorthosite boulders within the Blue Mountain quadrangle.

Pebbles and small boulders of Potsdam sandstone occasionally noted, even on mountain tops at altitudes of from 2500 to 3000 feet, are of special interest because of the long distance they have been transported, the nearest known outcrops being some 50 to 55 miles away in the St Lawrence and northern Champlain valleys. These erratics are always well worn and hard.

Kames and eskers. Kames, generally in groups, were sometimes observed, but the dense vegetation and lack of proper exposures have often prevented the definite recognition of this type of glacial deposit. A group of low kamelike hills spreads across the valley at the eastern end of Blue Mountain lake and forms the dam which holds up the water of the lake. Most of the area between South pond and Mud pond appears to be of kame or kame-morainic origin. Along the road between Long Lake village and Deerland (Grove) there are many good exposures of kame deposits, this being a fine example of an extensively developed, kame-moraine along the eastern side of the valley. Along the northern border of the quadrangle for several miles eastward from Long lake kames or kame-moraines are well developed.

A very typical esker about a mile long, 20 to 30 feet high, with winding course and just wide enough for the main road at its top, lies in Thirty-four marsh from 1 to 2 miles east-southeast of Blue Mountain Lake village. It consists of stratified sands and gravels. This esker looks much like an artificial embankment built through a portion of the swamp, very little grading having been necessary to convert it into a highway. About one-half of a mile southeast of the outlet of South pond, the main road follows another, though smaller and less typical, esker. These long, low ridges of stratified glacial materials were no doubt deposited in streams either at the bottom of the ice or in channels within the ice during the waning of the great ice sheet.

Moraines. Ground morainic material (till) is very widespread, particularly over the lower lands. As usual in the Adirondacks, it is very sandy or gravelly with numerous small to large embedded boulders. Typical boulder clay was nowhere noted. Ground morainic material is abundantly present in the vicinity of Indian Lake village, and in the Cedar river valley from the village westward for several miles. Good exposures may also be seen along the new state road for 8 or 9 miles eastward from Long Lake village, and along the road between 1 and 3 miles north of Blue Mountain Lake village. Perhaps the most extensive morainic deposits occupy much of the area from 1 to 5 miles east of Long Lake village and thence northward to the border of the quadrangle. Nothing like a distinct boulder moraine across the quadrangle or any portion of it was recognized.

Lakes and Their Deposits

Extinct lakes. In a general way it is important to note that extinct glacial lakes of considerable size are less common in this central Adirondack region than they are farther out toward the borders. In part this may be due to the fact that the central Adirondack region, which was first freed from the ice sheet, was too small to permit of much gathering of water against either the ice margin or morainic deposits across valleys. Also the relatively less thick morainic deposits were probably not so effective in forming dams across the valleys as they were when the ice had retreated much farther toward the borders of the region.

A series of small glacial lakes of short duration, and of successively lower levels, once occupied the bottom of the Cedar river valley between 3 and 8 miles west of Indian Lake village. Thus, between 7 and 8 miles west of the village the surface of a small lake stood at an altitude corresponding approximately to the 1880 foot contour. The delta sands, chiefly brought in by the large stream from the west, are well shown at several places along the road. Between $5\frac{1}{2}$ and 7 miles west of the village another lake stood at a level now corresponding to 1820 to 1840 feet with flat-topped delta sands well exhibited along the road. At a still lower level, from 3 to $4\frac{1}{2}$ miles west of Indian Lake village, there existed another glacial lake with delta sands now lying at about 1760 feet. These lakes were drained in succession either by retreat of the ice front or cutting down morainic deposits either of which must have formed dams across the valley.

Most of the swamp areas, particularly those of considerable size which are nearly flat, were formerly occupied by shallow lakes held up by drift dams, the lakes having been destroyed by filling with vegetable matter and sediment and cutting down of outlets. Excellent examples are the swamp areas along Sixmile brook and Fishing brook, just east of the south end of Tirrell pond; O'Neil flow; Thirty-four marsh; and just northeast of Indian Lake village.

Existing lakes. Existing lakes of the quadrangle illustrate all stages from those which are only remnants of formerly much larger bodies of water to those which are now nearly as large as they ever were. Some examples of the former are Unknown pond, the first of the Chain lakes, and the Grassy ponds; while examples of the latter are Long lake and Blue Mountain lake.

As already stated, there is no positive evidence that any lake occupies a true rock basin scoured out by the action of the great

ice sheet. The maximum depth of Blue Mountain lake is said to be about 90 feet. If so, it appears that this basin has, very locally at least, been ice eroded to a depth below any possible Preglacial outlet. The comparatively soft Grenville rocks of this basin would have been very susceptible to ice erosion. The basin of the third of the Chain lakes, mostly in soft Grenville limestone, is said to have a depth of 40 or 50 feet and it may thus also have been locally somewhat deepened by ice erosion.

The present water levels of the existing lakes all appear to be held up by glacial drift dams, usually across the outlets. Notable exceptions to dams across the outlets are Blue Mountain lake with drift dam across the eastern end, and Long lake with drift dam blocking a Preglacial channel on the east side of the present lake either $1\frac{1}{2}$ miles south of the outlet of the lake or about 2 miles northeast of Long Lake village. The first named locality is much the more likely as will be pointed out below. South pond, judging by the rock ledges across the outlet, appears to be held up by the heavy morainic deposits just southwest of the pond.

None of the existing lakes appear ever to have been more than 10 or 15 feet higher than their present levels. Along the shores of Long Lake there are occasional sand flats or delta deposits representing a former lake level 8 or 10 feet higher than the present. Perhaps the best of these sand flats is one-quarter of a mile long on the south side of the cove $1\frac{1}{2}$ miles southwest of Long Lake village. There is no evidence that Blue Mountain lake was ever more than a few feet higher than now.

Drainage Changes Due to Glaciation

As would be expected, because the watershed between the Hudson and St Lawrence basins passes across the quadrangle, there are certain rather delicately balanced drainage conditions.

Blue Mountain-Eagle lake basins. Before the ice age the basins now occupied by Blue Mountain and Eagle lakes quite certainly drained eastward into the Hudson river by way of Rock river instead of westward as at present through Raquette lake and thence northward into the St Lawrence (see figure 1). Evidence in support of this view is twofold, namely, the rock barrier at the eastern end of Utowana lake and the drift dam at the eastern end of Blue Mountain lake. Rock ledges are practically continuous across the narrow channel at the eastern end of Utowana lake, while the channel connecting Eagle and Blue Mountain lakes is entirely in

drift deposits. Thus the movement of water must here have been eastward in Preglacial time. Thirty-four marsh on Rock river comes to within one-half of a mile of Blue Mountain lake and it is about 20 feet lower than the lake surface, the intervening space being occupied by loose sands and gravels. It would be a simple matter, by shoveling out a trench nowhere over 20 feet deep, to cause Blue Mountain and Eagle lakes to drain eastward. Years ago such an attempt was actually made but stopped by law. The

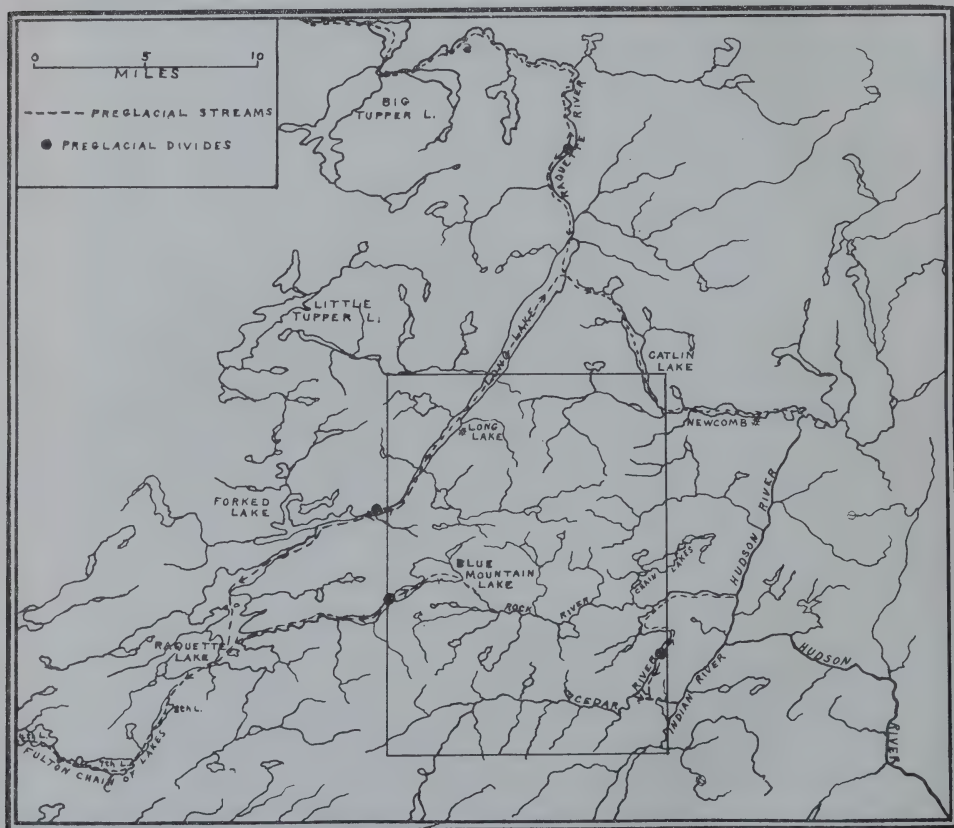


Fig. 1. Sketch map of a portion of the central Adirondack region showing the relations of the principal Preglacial stream courses to those of the present. Preglacial streams show only where essentially different from those of today. The rectangular area shows the position of the Blue Mountain quadrangle.

Preglacial drainage eastward through the lake basins was more in harmony with the course of the upper waters of Rock river which has its sources in and around Wilson pond about 3 miles southwest of Blue Mountain lake village.

Utowana-Raquette lake basins. That the Preglacial drainage through the Utowana lake basin passed westward into the basin

now occupied by Raquette lake is certain, there being only a drift dam at the western end of Utowana lake. From the Raquette lake basin the Preglacial drainage was either northeastward by way of Raquette river as now, or southwestward by way of the valley now occupied by the Fulton Chain lakes. Although this problem has not been carefully studied in the field, the presumption favors the southwesterly course. Thus, the interval of a mile between Brown's Tract inlet and Eighth lake is wholly occupied by drift deposits, while the valley occupied by the upper lakes of the Fulton Chain has its bottom covered with drift which, because of irregular thickness, at times acts as dams to pond the waters of the upper lakes. A maximum thickness of less than 100 feet of drift just north of Eighth lake is all that is necessary to account for the blockade of the southwesterly Preglacial channel with resultant ponding of the waters to form Raquette lake. Further evidence for this view lies in the fact that between Forked lake and Long lake, Raquette river descends more than 100 feet in about 3 miles mostly by a series of cascades over rock ledges which extend across the narrow channel. Apparently a Preglacial col was situated not far below the outlet of Forked lake, the drift accumulation southwest of Raquette lake being sufficient to pond the waters of the Raquette and Forked lake basins to overflow this col (see figure 1).

Long lake basin. Granting the source of a Preglacial stream on a col (near the outlet of Forked lake) a few miles above the upper end of Long lake, did this stream follow the present course of Raquette river into the St Lawrence? That the depression now occupied by Long lake was a Preglacial stream channel is certain, and also there is strong evidence that the drainage from this channel passed eastward into the Hudson river rather than northward by way of Raquette river. Regarding Raquette falls, on the river a few miles below the outlet of Long lake, Cushing says: "There is a fall of 70 to 80 feet in a gorge three-quarters of a mile long, in which the water is rapid throughout, but with two principal falls. There is an impassable rock barrier here, with no opportunity for a buried channel, so that there could have been no Preglacial drainage line; rather, there was here a col between small streams flowing both ways from the obstruction."¹ Thus, in Preglacial time, two streams drained into the depression now occupied by Long lake, one north-flowing from the col near the outlet of Forked lake (Raquette lake quadrangle), and the other south-flowing from the col at

¹ N. Y. State Mus. Bul. 95, p. 444. 1905.

Raquette falls (Long lake quadrangle). These streams met to flow eastward into the Hudson river, as Cushing has suggested, either through the Sixmile-Fishing brook valley in the northeastern part of the Blue Mountain quadrangle, or through the Catlin lake-Round pond valley in the southeastern part of the Long lake quadrangle. In the writer's opinion, the best evidence favors the Catlin lake-Round pond channel (see figure 1). The surface of Catlin lake is over 30 feet below that of Long lake and the two lakes are now separated by a divide of loose glacial debris only about 20 feet high. Years ago an attempt was made to cut a trench through this divide in order to drain Long lake through Catlin lake and thence into the Hudson river.

Sixmile-Fishing brook valley. The Sixmile-Fishing brook valley is heavily drift-filled, especially on the west where, in the vicinity of Polliwog pond, the drift at the bottom of the valley is nearly 100 feet above the level of Long lake. From its sources on Fishing Brook mountain, Fishing brook pursues a northwesterly course for several miles after which it swings sharply eastward to even south-eastward to near its mouth, thus showing a striking tendency to double back on its course. Sixmile brook also shows a sharp eastward swing. The more normal Preglacial courses of these streams would appear to have been westward into the Long lake valley. Evidently the eastward deflection of these streams was caused by glacial drift accumulations, especially in the vicinity of Polliwog pond, and the narrow gorge of Fishing brook cut in solid rock near the map edge is of Postglacial origin.

Cedar river. Near Indian Lake village a very low divide of loose glacial debris separates Cedar river and Indian river which are here only about 2 miles apart, the latter river being about 70 feet lower than the former. North of the village one-half of a mile, the crest of the divide is less than 20 feet above the level of Cedar river which is only two-thirds of a mile distant. West of Indian Lake village Cedar river pursues a meandering course with low gradient, while from 2 to 3 miles north of the village the river is very swift and usually confined to a deep, narrow, gorgelike channel in solid rock with no possibility of a buried channel on either side. Thus the evidence is clear that there was a Preglacial col between 2 and 3 miles north of Indian Lake village, and that the Preglacial Cedar river, which emptied into Indian river east or southeast of the village, was deflected over the col by the accumulation of drift north of the village.

ORIGIN OF RELIEF FEATURES

Influence of Rock Character

In common with the Precambrian rock area of northern New York in general, differences of rock character have been very influential in the production of the existing relief features of the quadrangle. Most important is the relatively weak Grenville formation which almost invariably occupies valleys or lowlands. As a result of the long Preglacial time of weathering and erosion, the Grenville strata were much more readily worn down than the very hard and resistant syenites and granites. Fine illustrations of this principle are the two prominent belts of Grenville represented on the southern half of the accompanying geologic map. One of these belts extends for 11 miles from the vicinity of Indian Lake village westward through the Cedar river valley, and the other from the vicinity of Pine lake westward nearly across the quadrangle to Blue Mountain lake, these two belts being connected through the valley south of Rock lake. There are smaller areas of Grenville from Unknown pond northeastward, and in the vicinity of the third of the Chain lakes. These Grenville areas include most of the lowest land of the southern half of the quadrangle, the prevailing rocks of the lowlands being Grenville limestone with more or less closely associated hornblende and pyroxene gneisses.

About $1\frac{1}{2}$ miles northwest of Indian Lake village the Grenville is much more resistant than usual, being a white feldspar-quartz gneiss which stands out 300 to 500 feet above the valley bottom. It is a very unusual example of this kind. The deep valley immediately south of Blue ridge has probably been developed by removal of a belt of Grenville. If so, the removal of the Grenville has been almost, if not quite, complete since no outcrop of such rock was anywhere found. The small fault at the eastern end of the valley may have been a factor in determining the location of the valley, but its influence was probably not sufficient to account for so large a valley. A similar explanation probably applies to the long, narrow depression between Blue mountain and the sharp ridge immediately to the south of it, and also to the deep depression now in part occupied by Tirrell pond.

The mixed gneisses, because of their considerable content of relatively weak Grenville, also tend to occupy the lower lands. Within such areas, the bolder relief features are due to the local presence of the more homogeneous and resistant igneous masses, the weaker

Grenville strata generally having been removed or at least much worn down parallel to the foliation. Two large areas — one across the northern side of the quadrangle, and the other south of Blue Mountain and Eagle lakes — afford fine illustrations of such phenomena. In those mixed gneiss masses where the Grenville is unusually resistant and intimately involved with the granite or syenite, the rocks may stand out in rather bold relief as, for instance, south and southwest of Unknown pond, and west of the south end of Long lake.

It is important to note that the main axis of elevation of the Adirondack region which extends across the Blue Mountain quadrangle is cut through by two of the few lowest passes with maximum altitudes of about 1800 feet. One of these is the Grenville valley across the quadrangle from Pine lake westward to Blue Mountain lake, and the other is the broad lowland belt of mixed gneisses across the northern side of the quadrangle.

The highest mountain masses always consist of facies of the great syenite-granite intrusive body with rarely more than slight amounts of admixed Grenville. Such rocks are exceedingly resistant to weathering and erosion, and it would require a very long time (a few million years perhaps) to cut down these mountains to the general level of the valleys now occupied by the Grenville strata.

The gabbro appears to be about as resistant as the syenite or granite, but its small masses do not permit any notable topographic influence. Where completely surrounded by weak Grenville, the gabbro usually stands out distinctly as small knobs like those either side of Sprague pond. The rather prominent gabbro knob between 3 and 4 miles east of Long Lake village shows outcrops of inclosing rock on one side only, and it is possible that more or less Grenville or mixed gneiss has been removed from around it.

Influence of Rock Structures

Where relatively weak Grenville strata dip downward against large masses of homogeneous syenite or granite, high and very steep slopes, simulating fault scarps, are usually developed as a result of weathering and erosion. Cases in point are the steep escarpment on the western face of the mountain from 1 to 2 miles south of Rock lake, and the steep eastern front of Waterbarrel mountain, each rising fully 700 feet. There is some reason to believe, as already suggested, that a mass of Grenville has been removed from

the depression now in part occupied by Tirrell pond. If so, the very steep mountainside just east of the pond (see plate II) may be accounted for in a similar manner.

Where weak Grenville beds overlie the granite or syenite, and both show moderate dips in the same direction, the effect has been to produce longer and more gentle slopes due to removal of the Grenville. In a general way, the whole southern side of the Cedar river valley from Indian Lake village westward illustrates this principle.

If granite or syenite and overlying Grenville both show steep dips in the same direction, removal of the Grenville may leave a steep slope, as seems to be the case on the mountainside just northwest of Blue Mountain lake.

The Blue Mountain region, unlike the eastern and southeastern Adirondacks, shows no prevalent tendency of mountain ridges to trend northeast-southwest because of faulting. Faulting has, however, been a prime factor in the production of a few important topographic features of the quadrangle, the known faults having been described above. We need only to repeat here that the straight, narrow depression the full length of Long lake; the straight, deep channel of Cedar river north of Indian Lake village; and the great depression which contains Indian lake all have been developed along fault zones of weakness. Very little of the topographic effect of the last named fault, however, shows within the Blue Mountain quadrangle.

Influence of Exfoliation

Exfoliation has produced some interesting, though comparatively minor, topographic effects. The steep eastern face of Water-barrel mountain is almost impossible of ascent because its upper 400 feet is completely covered with smooth, mostly barren exfoliation slabs from 50 to 100 feet across and several feet thick. As a result of the sliding of such great rock slabs down the scarp, and their breaking up into large angular blocks, an extensive talus deposit has been built up toward the base of the mountain. Because of gradual removal of weak Grenville strata which dip under the granite of this mountain, the face of the mountain has, for a long time, been retreating westward by splitting off of exfoliation slabs.

Other fine exhibitions of exfoliation on large scales are on the steep mountainsides northeast of Tirrell pond, east of Salmon

pond, and west of Salmon pond. In many other places more or less exfoliation was observed, but the ones above mentioned are the most interesting.

Influence of Glaciation

The glaciation of the quadrangle having already been described, it is now necessary to refer briefly to only a few effects of the ice sheet which have modified the relief.

Ice erosion appears to have modified the relief to a very minor extent only. The soil and rotten rock were largely scraped off down to the fresh rock particularly on the higher lands. Mountain masses may have been somewhat rounded off. As already pointed out, the basins of Long lake, Blue Mountain lake, and the third of the Chain lakes may have been locally slightly deepened by ice erosion.

The principal topographic effect of glaciation has been the almost universal tendency to accumulate the scraped off soil and rotten rock in the valleys. Accordingly the relief is lower now than at the time immediately preceding the ice age. Most of the valleys contain large accumulations of glacial debris, stratified and unstratified, with thickness up to several hundred feet. Most of the streams have only here and there cut through these deposits to the underlying rock.

The Cretaceous Peneplain

It is well known that toward the close of the Cretaceous period, a more or less well-developed peneplain existed over the northern Appalachian district, central and southern New York, the western side of the Adirondacks, and southern New England. As a result of the uplift and dissection of this great peneplain, the chief relief features of the northern Atlantic coast have been produced. Any very satisfactory evidence for a well-developed Cretaceous peneplain over the central and eastern Adirondacks has so far not been obtained, and the topography of the Blue Mountain quadrangle does not throw much light upon the problem. The most probable explanation is that the great masses of very resistant igneous rocks in the Adirondack region favored the existence of rather numerous and prominent monadnocks which rose above only a crudely developed peneplain surface. Hence it is difficult, if not impossible, to locate remnants of the peneplain surface with any certainty.

Within the Blue Mountain quadrangle, many mountain summits lie at altitudes of from 3000 to 3500 feet, with many others only a little higher or lower. This is well shown in the large mountain



Photo by E. E. Kellogg, Blue Mountain Lake, N. Y.
View westward across Tirrell pond. The barren portion of the mountainside shows the effect of the splitting off of large slabs of rock due to exfoliation.

group lying between Chain lakes and Long lake. Adjoining quadrangles show the common occurrence of similar altitudes. It would seem, therefore, that, if at all recognizable, remnants of the old peneplain surface now lie somewhere between 3000 and 3500 feet, altitudes higher than this representing what were the more prominent monadnocks. The concordance of altitudes is not very satisfactory, and so it must be admitted that the proof is by no means conclusive. At any rate, it is quite certain that the principal valleys and depressions of the quadrangle have been carved out of what was an upraised and at least crudely developed Cretaceous peneplain.

OUTLINE OF GEOLOGIC HISTORY

Those interested in the natural history of the Adirondack region, but not familiar with geologic lore, might do well first to consult the writer's New York State Museum Bulletin 168 entitled "The Geological History of New York State." This work has been prepared primarily for laymen. The only treatise on Adirondack geology in general is Cushing's excellent Museum Bulletin 95.¹ In the very brief summary immediately following, the attempt is to present only the most salient events now known to be recorded within the Blue Mountain quadrangle with some reference to the relation of these events to the geologic history of the Adirondacks in general.

Precambrian History

The oldest known geologic records in the Blue Mountain quadrangle are contained in the rocks of the Grenville series which, in the light of present knowledge, are to be grouped with the oldest known rocks of the earth's crust. Since these rocks are distinctly stratified, very thick (many thousands of feet), and of wide areal extent not only throughout the Adirondacks but also in eastern Canada, we may be sure that the earliest known condition of the area of the quadrangle was the presence of a sea in which the Grenville strata were being deposited layer upon layer. As yet nothing is known either regarding the floor of this very ancient sea or of the land masses from which the sediments were derived. During part of Grenville time the sea water was very clear as shown by the comparative purity of the great masses of limestone. That the Grenville ocean persisted for some millions of years is proved

¹ Since the above was written the author has prepared a small treatise for laymen entitled "The Adirondack Mountains." This contains an account of the geography and geology of the region in simple language. It is now being published by the New York State Museum.

by the great thickness of the sediments. A most conservative estimate by geologists gives the age of the Grenville strata as no less than 25 or 30 million years, though of course we have no means of accurately determining geologic time in terms of years.

After the deposition of the Grenville strata came vast intrusions of igneous rocks, including first the eruption of a great body of anorthosite mostly in Essex county and including the two small masses in the Blue Mountain quadrangle, and then the still greater bodies of syenite and granite, examples of which are so well shown in the quadrangle. Also the whole Adirondack region was raised well above sea level probably at or near the time of the eruption of the syenite-granite series. The tilting and metamorphism of the Grenville strata were most likely largely concomitant with the great igneous intrusions.

The great Precambrian land mass underwent profound erosion for some millions of years at least, extending through later Precambrian time and even into the early Paleozoic, as shown by the facts that the oldest rocks deposited upon the Precambrian are of late Cambrian age, and that the Precambrian rocks immediately below the Cambrian exhibit textures and structures which could have developed no less than some thousands of feet below the earth's surface.

Following the great intrusions and during the time of erosion above referred to came the minor intrusions of gabbro and diabase. The gabbro is definitely known to be much older than the diabase, the fine-grained texture of the former proving it to have cooled comparatively near the surface of the earth either in late Precambrian or very early Paleozoic time.

Paleozoic History

By late Cambrian time the profound erosion above mentioned had worn down the whole Adirondack region to the condition of a more or less well-developed peneplain. This we know because late Cambrian strata (particularly the Potsdam sandstone), which are the oldest to have been deposited upon the Precambrian, everywhere rest upon a peneplain surface of the Precambrian.

There is no evidence that Paleozoic strata were ever deposited over the area of the quadrangle, though late Cambrian or Ordovician strata now almost completely surround the whole Adirondack region. These Paleozoic rocks formerly mantled all but the central Adirondacks. A number of erosion remnants of the Paleozoic rock cover

still exist in the southeastern Adirondack region, the nearest to the Blue Mountain quadrangle being a small area of Potsdam sandstone near the village of North River about 16 miles a little south of east of Indian Lake village.

The best available evidence shows that the ancient peneplain became sufficiently submerged during late Cambrian time to allow the sea to cover all but a considerable part of the central Adirondack region, and that the maximum submergence occurred during mid-Ordovician (Trenton) time when only a comparatively small portion of the central Adirondack area (including the Blue Mountain quadrangle) remained as a small low island. During this Trenton time the sea may have extended over some of the southeastern portion of the Blue Mountain quadrangle, though of course any positive evidence is entirely lacking.¹

At some time (or times) during the middle or late Paleozoic era the whole Adirondack region, then largely mantled with Paleozoic sediments, was raised well above sea level. Some of the upward movement may have taken place at the time of the Taconic revolution (close of the Ordovician), though it is generally considered that the major uplift occurred at the time of the Appalachian revolution (toward the close of the Paleozoic). In northern New York this upward movement was not accompanied by folding, but there was a general tilting of the strata downward toward the south or southwest.

Mesozoic History

The erosion cycle inaugurated by the Paleozoic elevation of northern New York continued for a vast length of time or till the close of the Cretaceous period when the Paleozoic strata were largely removed from the Adirondack area and another eroded surface approaching the condition of a peneplain was produced. Apparently this peneplain was least perfectly developed in the central and east-central Adirondacks where various hard rock masses (monadnocks) stood out more or less prominently above the general peneplain surface. This peneplain was upraised about the close of the Cretaceous period so that remnants of it in northern New York now lie at altitudes of from 2000 to 3000 feet or possibly more. Within the quadrangle no very accurate idea of this peneplain or

¹Certain oscillations of level between land and sea, which are clearly recorded in the rocks around the Adirondacks, may also have affected the central Adirondack area, but the utter absence of all Paleozoic strata from the central area renders any determination of this kind difficult if not impossible.

its remnants can be gained because it was only imperfectly developed there.

It is quite certain that much of the faulting, including the Indian lake fault, which has so largely influenced the major topographic features of the southeastern half of the Adirondacks took place after the development of the Cretaceous peneplain and probably at the time of its uplift. Other zones of fracture, however, like the Long Lake fault, whose displacements show little if any in the existing topography, are probably much older, and they may in part at least be of even Precambrian age.

Cenozoic History

The existing relief features of the Blue Mountain quadrangle have been produced chiefly by the dissection of the upraised Cretaceous peneplain. As a result of the uplift the streams were greatly revived as erosive agents and they proceeded to carve out channels and valleys principally along the comparatively weak Grenville belts and the fault zones of weakness.

Late in the Cenozoic era the area of the quadrangle, in common with most of the State, was deeply buried under the great ice sheet of the glacial epoch. Many local details of topography, especially in the valleys, are due to accumulation of glacial deposits.

ECONOMIC PRODUCTS

As compared with many portions of New York State, the Blue Mountain quadrangle is notably deficient in geologic deposits of value under present-day commercial conditions. The lack of cheap transportation facilities prevents the working of certain deposits which might otherwise have some value. Building stones, so-called "road metal," sands and gravels for local use are the only materials now taken out. No ore deposit of any kind which may ever be successfully mined was observed by the writer. All the stone quarries and prospect holes of the quadrangle are indicated on the accompanying geologic map.

Building Stones

Fresh rock from any of the facies of the large masses of syenite or granite would yield building stones of great strength, resistance to weather and adaptability to high polish, but no large quarry exists in the region. Some typical greenish gray, quartzose syenite has been taken out for local use from the quarry one-half of a mile

northeast of Long Lake village. From two or three small quarries close together 1 mile northeast of Grove (Deerland) some pink granite has been taken out. Near the dam across the end of Indian lake two considerable openings have been made in the granite porphyry to furnish stone for the masonry of the dam.

Road Metal

The building of state roads between Grove (Deerland), Long Lake, and Newcomb has caused the recent opening of several large road metal quarries within the quadrangle. One of these is in typical, greenish gray, quartzose syenite on the road $1\frac{1}{2}$ miles southwest of Long Lake village. This rock makes a good grade of road metal.

Another quarry in pink granite, and a third in greenish gray granite are situated along the road about $2\frac{1}{2}$ and 7 miles, respectively, east of Long Lake village. On account of their content of mica, these granites are not quite so satisfactory for road work as the normal and basic facies of syenite or gabbro. The large body of gabbro, crossed by the road between 4 and 5 miles east of Long Lake village, was not used for state road work but it would have been excellent for the purpose on account of its richness in iron-bearing minerals.

In some cases the coarse, crystalline Grenville limestone, where sufficiently weathered to crumble easily, is used to repair roads. Such limestone is taken from the pit indicated on the map one-third of a mile northwest of where the road crosses Cedar river.

Sand and Gravel

Sand and gravel of good quality are present in abundance, especially in the valleys where the sorting power of Glacial and Post-glacial streams has been most effective. Such materials are taken from many localities for road and concrete work and for making mortar.

Garnet Deposits

The development of the garnet industry in northwestern Warren county has led to considerable exploration for similar workable deposits for some miles around Indian Lake village. At two places, indicated on the map, respectively $1\frac{1}{2}$ miles southeast and $2\frac{1}{4}$ miles south-southeast of Forest House, several small prospect holes have been opened in the hornblende gneiss which is so commonly associated with Grenville limestone. At the first-named locality the

garnets are of the red almandite variety up to 5 inches in diameter, and without hornblende rims, while at the second-named locality similar garnets up to 6 or 7 inches in diameter are enveloped in black hornblende, these latter, therefore, presenting an appearance very similar to those long known from the mine on Gore mountain in Warren county near North Creek. It is this Grenville, hornblende gneiss which is most likely to yield large garnets, but lack of transportation facilities and the general condition of the garnet market have thus far prevented any real mining within the quadrangle. A number of years ago some garnet was shipped from an excellent deposit, similar to those above described, about $2\frac{1}{2}$ miles northeast of Indian Lake village (one-half of a mile east of Bull-head pond) on the adjoining Newcomb sheet. Garnets are crushed and used for abrasive purposes.

Feldspar

For some years those engaged in pottery and chinaware industries have been seeking suitable deposits of feldspar. While feldspar is the most common mineral within the quadrangle, it is not commercially valuable unless occurring as the white potash (orthoclase) variety in large masses, usually in pegmatite dikes or veins. There are many pegmatite dikes ranging from a few inches to a hundred feet wide within the quadrangle, but none promising to be of commercial value could be located. Some of the largest observed deposits are located as follows: 1 mile a little east of north of Indian Lake village where there is a dike or vein about 15 feet wide and 40 or 50 feet long; just southeast of the small gabbro stock on the largest island in Blue Mountain lake and in contact with the gabbro on the west, this dike being fully 100 feet wide and 200 yards long; and a dike 10 or 15 feet wide cutting Grenville hornblende gneiss on Cedar river $3\frac{1}{2}$ miles west of Indian Lake village.

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The University of the State of New York New York State Museum

JOHN M. CLARKE DIRECTOR

THE ADIRONDACK MOUNTAINS

By WILLIAM J. MILLER

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The University of the State of New York

Department of Science, January 23, 1917

Dr John H. Finley

President of the University

SIR:

I beg to communicate herewith, and to recommend for publication as a bulletin of the State Museum, the accompanying manuscript entitled "The Adirondack Mountains." This has been prepared as a somewhat untechnical guide to the geology and physiographic history of the Adirondack mountain region.

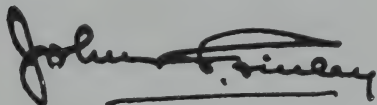
Very respectfully

JOHN M. CLARKE

Director

THE UNIVERSITY OF THE STATE OF NEW YORK
OFFICE OF THE PRESIDENT

Approved for publication this 25th day of January 1917

A handwritten signature in dark ink, appearing to read "John H. Finley". The signature is written in a cursive style with a horizontal line underneath the name.

President of the University

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JOHN M. CLARKE, *Director*

THE ADIRONDACK MOUNTAINS

BY WILLIAM J. MILLER

Professor of Geology in Smith College

Member of the Staff of the New York State Museum

PREFACE

Among the thousands of people who visit the Adirondack mountains each summer, many are real lovers of nature and would welcome a brief scientific treatment of geographic and geologic features of the region. Most Adirondack visitors, however, have little conception of the origin and history of the mountains, though they are often good observers who find numerous interesting but frequently very puzzling things among the relief features and the rocks of the region. During the last ten summers, while engaged in the state geologic surveys of various portions of the Adirondacks, hundreds of people have asked the writer if there were not some popular scientific account of the natural features of the region. This brief volume has been prepared as an answer to these inquiries. To those who have found the charm of the Adirondacks it is my earnest wish that this book may, in simple language, explain how the more obvious and accessible physical features of the mountains came to be as we see them today after profound revolutionary changes through tens of millions of years of history. If a fuller knowledge is desired of a portion or all of the Adirondacks, the principal publications thereon will be found listed in the appendix.

Whoever writes upon the geology of this region is under abundant obligation to his coworkers in the same field. The foundation

of our knowledge of this ancient region was laid by Dr Ebenezer Emmons in 1836-42, when State Geologist in charge of the second geological district. For fifty years after his day no systematic effort was made to elucidate the intricate geological problems of the region, but in 1891 a closer study was organized by the State Geologist and the field was entered by Prof. James F. Kemp, Prof. Charles H. Smyth, and Prof. Henry P. Cushing, with their associates. All these geologists have maintained to the present time their active interest in the mountain region, and to them, their associates and successors we owe our present understanding of Adirondack geology. The writer has been for ten years a worker in this field under the auspices of the State Geological Survey.

INTRODUCTION

Some General Principles of Earth History

The observer who looks out over the Adirondack region sees a great variety of physical features and, unless he has given some study to the subject, is very likely to regard these as practically unchangeable, and to think that they are now essentially as they were in the beginning of the earth's history. But the physical features of the Adirondacks, as we behold them today, represent merely a single phase of a very long continued history. As a result of the work of many able students of earth science during the past hundred years, it is now well established that our planet has a clearly recorded history of many millions of years, and that, during the lapse of those eons, revolutionary changes in geography have occurred, and also that there has been a vast succession of living beings which, from very early times, have gradually passed from simple into more and more complex forms. The geographic changes and the organisms of the past ages have left abundant evidence of their character, and the study of the rock formations has shown that within them we have a fairly complete record of the earth's history. While it is true that very much yet remains to be learned about this old earth, it is a real source of wonderment that man, through the exercise of his highest faculty, has come to know so much concerning it.

Geology, meaning literally "earth science," deals with the history of the earth and its inhabitants as revealed in the rocks. This science is very broad in its scope and treats of the processes by which the earth has been, and is now being, changed; the structure of the earth; the stages through which it has passed; and the evolution of the organisms which have lived upon it.

Geography deals with the distribution of the earth's physical features, in their relation to one another, to the life of sea and land and human life and culture. It is the present and outward expression of geological effects. The terms geography and geology are thus here used in the sense that the latter includes the former, as the cause includes the effect.

"The great lesson taught by the study of the outer crust is that the earth-mother, like her children, has attained her present form through ceaseless change, which marks the pulse of life and which shall cease only when her internal forces slumber and the cloudy air and surf-bound ocean no more are moving garments. The flowing landscapes of geologic time may be likened to a kinetoscopic panorama. The scenes transform from age to age, as from act to act; seas and plains and mountains of different types follow and replace each other through time, as the traveler sees them succeed each other in space. At times the drama hastens and unusual rapidity of geologic action has in fact marked those epochs since man has been a spectator upon the earth. Science demonstrates that mountains are transitory forms, but the eye of man through all his lifetime sees no change, and his reason is appalled at the conception of a duration so vast that the milleniums of written history have not accomplished the shifting of even one of the fleeting views which blend into the moving picture."¹

All the rocks of the earth's crust may be divided into three great classes: *igneous*, *sedimentary* and *metamorphic*.

Igneous rocks comprise all those which have ever been in a molten condition, and of these we have the *volcanic* rocks (for example, lavas), which have cooled at or near the surface; *plutonic* rocks (for example, granites), which have cooled in great masses at considerable depths below the surface; and the *dike* rocks which, when molten, have been forced into fissures in the earth's crust and there cooled.

Sedimentary rocks comprise all those which have been deposited under water, except some wind-blown deposits, and they are nearly always arranged in layers (stratified). Such rocks are called strata. They may be of mechanical origin such as clay or mud which hardens to *shale*; sand, which consolidates into *sandstone*; and gravel, which when cemented becomes *conglomerate*. They may be of organic origin such as *limestone*, most of which is formed by the accumulation of calcareous shells; *flint* and *chert*, which

¹ Joseph Barrell. Central Connecticut in the Geologic Past, p. 1-2.

are accumulations of siliceous shells; or *coal*, which is formed by the accumulation of partly decayed organic matter. Or, finally, they may be formed by chemical precipitation, as beds of *salt*, *gypsum*, *bog iron ore*, etc.

Metamorphic rocks include both sedimentary and igneous rocks which have been notably changed from their original condition. Thus, under conditions of moisture, heat and great pressure, sedimentary rocks may become crystalline, as when shale is changed to *schist*, sandstone to *quartzite*, or limestone to *marble*; or an igneous rock may take on a streaked or crudely banded structure due to more or less flattening and rearrangement of its component minerals, and thus become a *gneiss*.

To the modern student of earth science the old notion of "terra firma" is outworn. That idea of a solid, immovable earth could never have emanated from the inhabitants of an earthquake country. Earthquakes are caused by sudden movements in the crust of the earth, most commonly resulting from slipping of one part past another along a fracture. Such fractures, known as "faults," are very common in the southeastern half of the Adirondacks. In the San Francisco earthquake of 1906, along a fracture line of several hundred miles, one portion of the Coast Range mountains suddenly slipped from two to twenty feet past the other. In Alaska in 1899, a portion of the coast was bodily elevated forty-seven feet. In Japan in 1891, for a distance of forty miles along a rift in the earth's crust, there was a sudden movement of from ten to forty feet. These are merely striking instances of many of the sudden earth movements of recent years. It is probably true that the earth is shaking some place all the time.

Still other movements take place more slowly and quietly, but they are very significant for our interpretation of the profound geographic changes which have occurred during the millions of years of earth history. Such movements are now known to be taking place. Thus the northern portion of Sweden is rising several feet a century, while the southern portion is sinking. A fine illustration of notable sinking of the land is proved by the drowned character of the lower Hudson valley, and by the fact that the old Hudson channel has been definitely traced as a distinct trench in the ocean bottom for one hundred miles eastward from Sandy Hook. That this same region has been more recently partially reelevated is indicated by the presence of very young stratified clay beds and sands which are now raised from zero near New York

City to five or six hundred feet at the northern end of Lake Champlain, the elevation gradually increasing northward. Actual surveys show that, in the Great Lakes region, a differential movement of the land is now in progress, the elevation being greater toward the north. Recent changes of level in the Adirondack district will be described toward the close of the next chapter.

Among other important processes which have long been active in modifying the earth are those of *weathering* and *erosion*. Weathering is brought about by the various atmospheric agencies such as moisture, oxygen, carbonic acid gas, etc., together with changes of temperature. The result is to cause all rock masses to disintegrate or decay in the course of time. In this way most soils are produced. In northern New York the original soils of this sort have been very largely reworked and redeposited by the ice or by streams of water in connection with the ice during the great Ice Age. Were it not for the process of erosion, which includes both the breaking up and removal of rock material, soils would be much more widespread than they now are. Weathering prepares the material which is carried away by the streams, and this material is mostly deposited either along the flood-plains of the lower stream courses, or on the bottoms of lakes or oceans into which the streams flow. Every stream, at time of flood, is heavily charged with mud or even coarser sediment which has been derived from the wear of the land of its drainage basin. The very presence of the sediment in the streams proves that the land is being lowered, and although, on first thought, it may be supposed that no really great change could be accomplished by this means, nevertheless we must remember that nature has practically infinite time at her disposal so that slowly but surely vast physical changes are wrought and, perchance, a tremendous canyon like that of the Colorado river in Arizona may be carved out by erosion. The general tendency is for all land masses to wear down to or near sea level and, were it not for renewed earth movements, all lands, even including the mountains, would be thus worn down to what is known as a *peneplain* condition. Northern New York was worn down to the condition of a more or less well-developed peneplain at least twice during its long history. Accordingly, that familiar expression "the everlasting hills" is decidedly incorrect.

Another important process is *vulcanism*, that is to say, igneous activity in general. By this means materials are brought up from within the earth to or near its surface. Thus an active volcano

ejects rock fragments, dust etc., or more quietly pours out molten rock, while in many cases great masses of molten rock have been forced upward into the earth's crust without reaching the surface and hence have cooled at greater or lesser depths below the surface. Such deep-seated (plutonic) igneous rocks have become exposed to view only by subsequent profound erosion of the region.

Still another process which has been very influential in the production of certain important physical features of the Adirondacks is *glaciation*. During the great Ice Age, comparatively recently, a vast sheet of ice slowly moved across the whole region and then gradually melted away. Its principal work was erosion and deposition of rock materials, the latter having taken place chiefly during the ice retreat. Most of the soil and rotten rock and some fresh rock were scraped off by the mighty ice plow, and the irregular deposition of the glacial débris brought into existence many minor topographic features. The Adirondack lakes are practically all due to the glaciation.

Geologic time scale

LENGTH IN YEARS	ERA	PERIOD	DOMINANT LIFE
3 to 5 million..	Cenozoic.....	Quaternary.....	Age of man
		Tertiary.....	Age of mammals
5 to 10 million..	Mesozoic.....	Cretaceous.....	Age of reptiles; first birds in the Jurassic; first modern plants in Cretaceous
		Jurassic.....	Age of amphibians and cycad plants
		Triassic.....	Great coal age, with large, simple non-flowering pl nts
		Permian.....	
		Pennsylvanian.....	
15 to 25 million..	Paleozoic.....	Mississippian.....	
		Devonian.....	Age of fishes
		Silurian.....	
		Ordovician.....	Age of invertebrate animals
		Cambrian.....	
		Keweenawan.....	
		Animikean.....	
.....	Proterozoic...	Huronian.....	Simple forms of life; records imperfect
		Algonian.....	
		Sudburian.....	
.....	Archeozoic....	Laurentian.....	Beginnings of life
		Grenville.....	

In order to understand the physical history of the Adirondacks, it is necessary to know that the history of the earth has been divided into great eras and lesser periods and epochs, and that these constitute what is called the geologic time scale. The epoch names for eastern North America are omitted from the above table. So far as they are recorded, the principal events in the history of the Adirondacks will be taken up in the regular order of geologic time in the following pages.

Sources of Information

The purpose of this book is not to give detailed discussions of particular portions of the Adirondack mountains, but rather to present, in simple, nontechnical language, a general outline of the geography, rock formations, physical history, and human history of the region. In fact much of the area has not yet been geologically mapped or studied in detail. Most of the important and striking physical features of the Adirondacks, however, are explained, and many local details will find ready explanation by the application of the principles set forth.

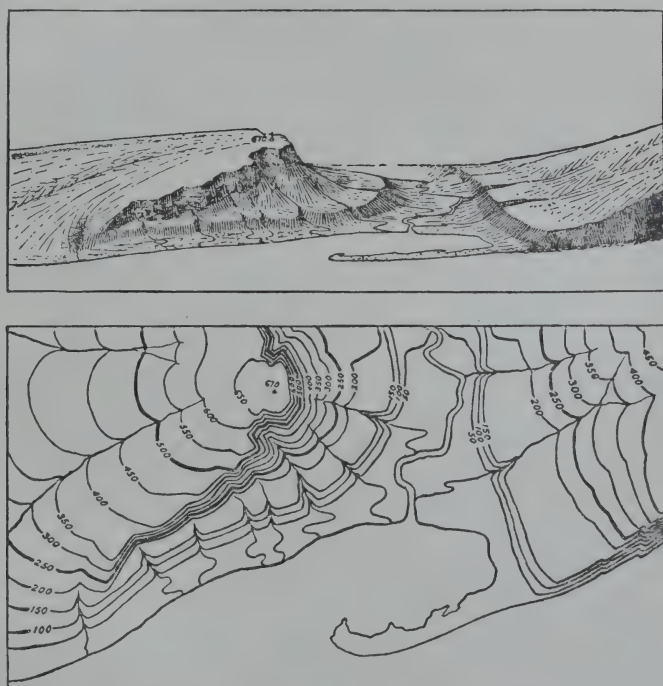


FIG. 1 A landscape and corresponding contour map. (After United States Geological Survey).

The attention of those who may be sufficiently interested is called to the various publications pertaining to Adirondack geography, geology and human history. Most of the more important of these are listed in the appendix. The New York State Museum Bulletins, which contain topographic and geologic maps and explanatory texts regarding certain specified areas, are of special importance. These

may be obtained at small cost on application to the Director of the State Museum at Albany. The areas thus mapped in detail to date are indicated on map figure 2.

There are excellent maps showing the topography (surface configuration) of most of the Adirondack mountain district. These topographic (or contour) maps, which are called sheets or quadrangles, are rectangular in shape and bounded by latitude and longitude lines. Each map is about $17\frac{1}{2}$ inches high by 12 to 13 inches wide, the latter varying with the latitude. The scale is 1 to 62,500 or nearly one mile to one inch, that is, a mile on the ground is

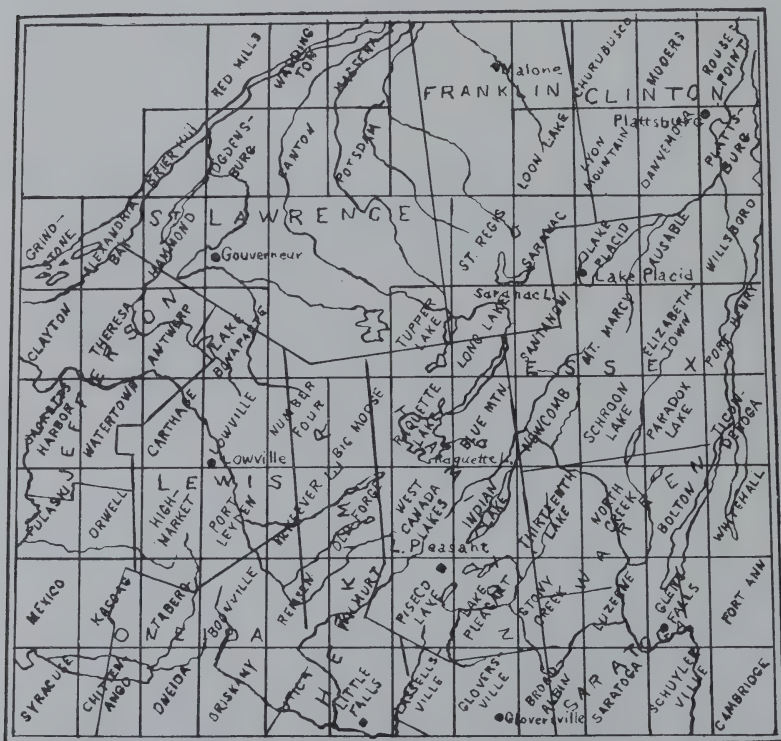


FIG. 2 Sketch map of northern New York showing the names and locations of the various topographic maps (quadrangles) published by the United States Geological Survey in cooperation with New York State to January 1916. Geological maps of the following quadrangles have been published by the New York State Museum: Little Falls, Broadalbin, Saratoga, Schuylerville, Lake Pleasant, Remsen, Port Leyden, North Creek, Paradox Lake, Port Henry, Elizabethtown, Long Lake, Blue Mountain, Alexandria Bay, Grindstone, Clayton, and Theresa. Geologic maps soon to be published are: Schroon Lake, Lake Placid and Mount Marcy.

represented by an inch on the map. The most valuable feature of these maps is the fact that the relief (topography) of the country is so accurately represented, this feature being explained by the accompanying figure and the description generally printed on the back of each map. The relief is shown by contour lines in brown, every point on a given contour being at the same altitude above sea level. On the Adirondack maps the contour interval, that is, vertical distance represented between any two contour lines, is 20 feet. Water features are shown in blue. Artificial features, such as roads, trails, railroads, boundary lines, houses, villages etc., are shown in black. Each quadrangle map is designated by the name of some geographic feature. The maps are published by the United States Geological Survey, and orders for them should be sent to the director of that bureau at Washington, D. C. They are sold at ten cents each when fewer than fifty are purchased, but in lots of fifty or more of the same or different maps, the price is six cents each. Orders should be accompanied by cash or a post office money order. All except the northwestern border of the Adirondack region has been covered by these topographic maps. Figure 2 is an index to both the topographic and geologic maps thus far published.

Any person interested in the geographic setting of any portion of the Adirondacks should procure the proper topographic sheets of that region and thus be provided with the best map of the sort in existence. It would be difficult to overestimate the value of these maps to teachers and pupils of geography, and every school should be provided with a supply of them.

GEOGRAPHY OF THE ADIRONDACKS

General Features

The Adirondack mountain region of northern New York is a very distinct topographic province comprising nearly one-fourth of the area of the State, or about 11,000 square miles. It is an irregular, broad, oval-shaped region with longest axis running 120 miles north-northeast by south-southwest, and short axis 100 miles east and west. The name "Adirondack," meaning "Tree-eater," was a term of contempt applied by the Indians of the south (Iroquois) to the Indians who lived on the northern slope of the mountain region and in the St Lawrence valley. Professor Emmons, in his geological survey of northern New York about 1840, is said to have first applied the name "Adirondack" to a northeast-southwest mountain belt including the highest peaks of the present Adirondack area. Later the term came to be applied to the whole of the mountain region sometimes called the "Great North Woods" or the "Great Wilderness of Northern New York."

The Adirondacks consist almost wholly of a mass of igneous and metamorphosed sedimentary rocks of very great age, that is, pre-Paleozoic. This very ancient rock mass is surrounded by practically unaltered strata of early Paleozoic age.

The whole region is typically mountainous and rugged, with altitudes ranging from 1000 to over 5000 feet, except around the borders. Most of the Adirondacks are heavily wooded, often being truly wilderness in character with very few roads, trails or settlements except scattering camps or summer resorts. In southern Hamilton county, for example, there is an area of 125 square miles without a traveled road or permanent settlement, and with very few trails. Again, most of the Santanoni quadrangle (over 200 square miles) of the east-central Adirondacks has only a few miles of traveled road and very few trails. The writer has had much experience in both the Sierra Nevada mountains of California and in the Adirondacks, and he can testify to the fact that it is decidedly easier to keep one's bearings in the higher, grander mountains of the West. Reasons for this are that in the Adirondacks few mountain peaks rise notably and characteristically above the general mountain summits; the country is so densely and monotonously wooded, usually with thick underbrush, that one might travel for miles without finding a good outlook point; and most of the stream courses are exceedingly irregular and difficult to follow

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MAP OF THE ADIRONDACK MOUNTAIN REGION

SHOWING THE PRINCIPAL RAILROADS,
VILLAGES, STREAMS, LAKES AND
MOUNTAINS (WITH ALTITUDE)

SCALE OF MILES

0 5 10 20 30 40



because of dense growth of brush or swamps. Most of the Adirondack region is, in the real sense of the term, a well-watered, densely wooded, wilderness. There are, however, hundreds of places throughout the mountains where large tracts are clad with forests relatively free from underbrush, where the lover of the deep, gloomy woods, may roam to his heart's content with comparative ease, and many mountain summits from which magnificent panoramic views may be enjoyed.

There are many large areas which have been ravaged by forest fires. A few years after such a fire a dense thicket of raspberry and blackberry briars, popple, and other brush grows over the fallen, charred tree trunks and loose rocks, rendering such an area exceedingly difficult to traverse. There are also many portions of the Adirondacks where lumbering operations have recently been carried on. Such districts, with treetops and other lumberman's refuse piled pell-mell, are also difficult to cross. Mountain ridge summits from 3000 to 4000 feet above sea level often have thickets of scrub evergreen trees so densely intergrown that it is the hardest kind of work to make progress through them at the rate of one-half to one mile an hour. It is therefore not at all surprising that one is frequently lost in the woods. Persons not well acquainted with the Adirondack type of country should be careful not to wander away from well-defined trails or roads unless accompanied by a competent guide or some other person who really understands the region.

The excellent water of the Adirondacks deserves mention. Nearly all the streams which come down the mountain sides are clear, cold, pure and remarkably soft water. Springs and streams of such water are abundant throughout the summer season. Practically the only hard water issues as springs out of the limestone which underlies certain of the valleys.

Except for an occasional rattlesnake at the very southeastern border of the Adirondacks, poisonous reptiles are unknown. Hence one may follow the trails, travel through the woods, or climb the mountains without the slightest dread of encountering a rattlesnake, copperhead, or any other dangerous reptile. In fact it may be affirmed that no Adirondack wild animal is really dangerous, which is a matter of great importance when considering the Adirondacks as a playground for the people. Bears are occasionally seen and sometimes killed but, in common with that of many persons, the writer's experience is that the Adirondack black bear loses little time in getting out of sight of a human being. Of course a

mother bear with cubs is likely to put up a fight if really molested or cornered. Thousands of deer roam the "Great North Woods" and they are very frequently seen. During the open season in the fall hundreds of hunters go to the woods and many deer are killed. Red foxes are fairly common, while a silver fox is rarely seen. Squirrels, rabbits and porcupines (hedgehogs) are common. Partridges are very abundant in nearly all parts of the Adirondacks. Hawks are common and American bald eagles rare. Many of the lakes and streams afford good trout and bass fishing, especially early in the season.

Much of the Adirondack area is now owned by the State of New York, and gradually more of the land is being acquired. Camping privileges are free to all on state land. All but the borders of the "Great North Woods" lies within the boundaries of the so-called "Adirondack Park," it being the purpose of the State to gain possession of more and more of the land within the confines of the park. Too much can not be said in favor of this project to control the great, wild, mountainous region as a recreation park and watershed for the benefit of the people.

Surrounding Valleys

With a single slight exception on the southwestern border, the Adirondacks are completely surrounded by prominent valleys whose bottoms are nowhere more than a few hundred feet above sea level. These are the St Lawrence, Champlain, Mohawk and Black River valleys.

The St Lawrence valley, bounding the Adirondacks on the north, is a great open depression of comparatively simple structure and near sea level. Where the river leaves Lake Ontario the altitude is only 247 feet, while points more than a few hundred feet above the sea are comparatively rare. The Thousand Islands form a remarkable feature of the valley where the wide, clear, slow-moving St Lawrence river does not occupy any very distinct channel, but rather flows across a broad, low, hilly region of very moderate relief, thus allowing many of the rocky hills to stand out as islands. The rocks of the valley are chiefly sandstones and limestones of early Paleozoic age, though in the vicinity of the Thousand Islands numerous patches of older (underlying) and much harder pre-Paleozoic rocks are exposed as on many of the islands themselves. The Paleozoic strata form a comparatively thin mantle of nearly horizontal layers over the pre-Paleozoic rocks.

The Champlain valley bounds the Adirondacks on the east, being a great depression which separates the Green mountains on the east from the Adirondacks on the west. Much of the valley bottom is filled by the waters of Lake Champlain, whose altitude is 101 feet. Along the western shores of the lake the topography is characteristically hilly, though seldom above 500 feet in elevation. The transition to the higher and rugged Adirondacks is generally rapid.

Bounding the region on the south, the Mohawk valley clearly separates the Adirondacks from the highlands of the Catskills and the great southwestern plateau of New York. The comparatively narrow inner valley through which the river flows is often erroneously called the Mohawk valley, but in reality the whole depression, from 10 to 30 miles wide and fully 1000 feet deep, between the northern and southern highlands of the State should be called the Mohawk valley. The bottom of the valley is only 300 to 400 feet above sea level. At Little Falls the inner valley narrows to a gorge several hundred feet deep where the river has cut its way through an old divide. The principal rocks of the valley are shales, sandstones and limestones of Cambrian and Ordovician ages, with Ordovician shales predominating. The great depression owes its existence largely to the presence of this belt of soft shales lying between the hard ancient rocks of the Adirondacks on the north and the relatively hard limestones immediately south of the valley. The work of erosion has made rapid progress in this belt of weak rocks, and at two places, Little Falls and Yosts ("The Noses"), the river has cut through to the underlying pre-Paleozoic (Adirondack) rock. In general, the strata of the valley tilt only slightly southward and show little signs of folding (fig. 7), though from Little Falls eastward there are various faults (fractures) in the strata.

On the west, the Adirondack highland is bounded by the Black River valley, which is about 60 miles long and has a maximum depth of nearly 1500 feet. Immediately west of the valley the Tug Hill plateau stands out as a distinct, isolated geographic province. The top of the plateau, covering many square miles, is remarkably flat, swampy and densely wooded with altitudes ranging from 1800 to 2100 feet. This Tug Hill plateau is merely an erosion remnant of a great upraised plain which formerly covered the area of New York State (see page 50). Near Boonville, at an altitude of about 1100 feet, occurs the division of drainage between the Black and Mohawk rivers, this divide not only forming the highest connection between the Tug Hill plateau and the Adirondacks, but also being

the highest valley bottom immediately surrounding the Adirondacks. Disregarding the loose, comparatively recent glacial deposits, the eastern half of the Black River valley shows the very ancient Adirondack (pre-Paleozoic) rocks only, while on the western side there are early Paleozoic strata only piled up to a thickness of 1500 feet with slight westward tilt (see figure 12). These strata are limestones, shales and sandstones.

Mountains

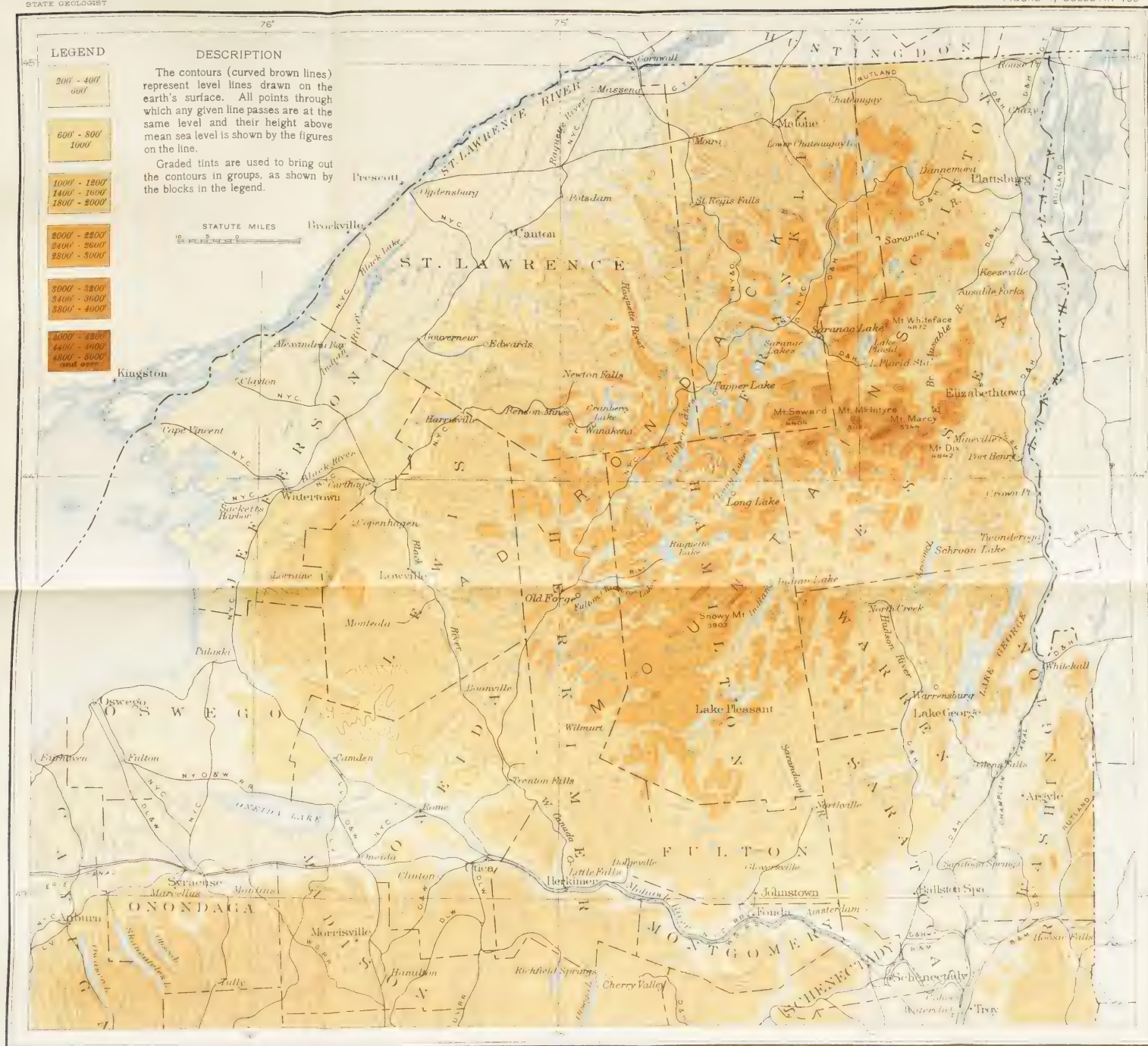
The mountains and valleys of the Adirondack region are the present outward expression of an exceedingly long history. An outline of this history will be presented in the next chapter, the purpose now being to describe the principal topographic (relief) features without much explanation of their origin.

Viewed in a broad way, the Adirondack mountains and valleys are very irregularly arranged, this being due largely to the exceedingly patchy distribution of the relatively harder and softer rocks, as explained below, the harder rock masses having stood out most against weathering and erosion to form the mountains. There are no long, distinct, approximately parallel ridges (so-called "ranges") such as characterize the Appalachians. In the southeastern half of the Adirondacks there is a considerable tendency for many of the mountain masses to be arranged as roughly parallel short ridges with north-northeast by south-southwest trend. This structural feature is due to the fact, as will be explained in the next chapter, that this portion of the region has been highly fractured (faulted), the principal fractures trending parallel to the north-northeast by south-southwest ridges. There are, however, many exceptions to this parallelism of mountain masses, while very few of the ridges are as much as 10 miles long and many of them are not very sharply defined as ridges because of notable variations in width and altitude in individual cases. In spite of this moderate tendency toward parallelism, the Adirondacks are, as the map (figure 4) suggests, a jumbled mass of very irregularly shaped, relatively low mountains.

By far the greatest number of mountains rise from 1000 to 3000 feet above sea level; a considerable number reach altitudes of 3000 to 4000 feet; while very few are over 4000 feet, the highest of all being Mt Marcy in the east-central portion (Essex county). This east-central portion contains the group of loftiest mountains in the Adirondacks, most of the highest ones showing altitudes in feet

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GENERALIZED TOPOGRAPHIC MAP OF NORTHERN NEW YORK

as follows: Mt Marcy, 5344; Mt McIntyre, 5112; Mt Skylight, 4920; Mt Haystack, 4918; Mt Whiteface, 4872; Dix mountain, 4842; The Gothics, 4738; Mt Colden, 4713; Giant mountain, 4622; Santanoni mountain, 4621; Nipple top, 4620; Mt Redfield, 4606; Saddleback mountain, 4530; Armstrong mountain, 4455; Panther peak, 4443; Table Top mountain, 4440; McComb mountain, 4425; and Seward mountain, 4440. All these high peaks, except Seward mountain, are in the northwestern half of Essex county and confined to an area of five or six hundred square miles. These are the loftiest mountains in eastern North America except the Blue ridge of North Carolina and the White mountains of New Hampshire. "The individual mountains are diversified in shape. Mt Marcy is a very low cone, and the last stages of its ascent are very much like climbing a dome. Mt McIntyre has a gradual slope from the northwest, but a precipitous escarpment on the southeast. The Gothics are like a steep wedge standing on its base, and tapering from all four sides of the base to the ridge. Whiteface is a long sharp ridge, steep if not actually precipitous on each side, and leading up to a peak at the southwestern end. Some buttresses run out from the ridge and make beautiful cirques on its flanks. Hurricane, when viewed from the east, resembles a sharp volcanic cone; from the west it is flat. There are several, of which Dix is the highest example, which, like Vesuvius, have a small conical summit set upon a large mountainous base. Nipple top is a rather favorite name in the local nomenclature of the inhabitants. There are several smaller mountains which have the outlines of a steep haystack when viewed from certain directions, and their precipitous sides and doming tops fix the eye at once. Yet they may each be a ridge when seen from the opposite."¹

Next to the highest mountain district is the northern half of Hamilton county where many points reach altitudes above 3500 feet, though none quite reach 4000 feet. Some of the highest of these from north to south are: Fishing Brook mountain, 3550; Dun Brook mountain, 3565; Blue mountain, 3759; Wakeley mountain, 3617; Panther mountain, 3865; Snowy mountain, 3903; Little Moose mountain, 3630; Lewey mountain, 3740; and Blue Ridge mountain, 3865.

What has been termed the main axis of elevation, including the highest points, through the Adirondacks runs south along the Franklin-Clinton county boundary and to the vicinity of Mt Marcy;

¹ J. F. Kemp. *Popular Science Monthly*, March 1906, p. 197-99.

thence it swings abruptly westward into southern Franklin and northwestern Hamilton counties; and thence southward clear through Hamilton county. Toward the north two deep, narrow valleys have been cut across the main axis by the two chief branches of the Saranac river. From there southward the two lowest passes across the main axis of elevation are long relatively broad valleys with maximum altitudes of about 1800 feet, one extending east-west across the northern part of the Blue Mountain quadrangle, and the other east-west through Raquette and Blue Mountain lakes.

Valleys

It is almost impossible to think of the mountains apart from the valleys. Like the mountains, the Adirondack valleys are also exceedingly variable in size, shape and distribution. In general there are three types of valleys, one of which is broad, open and usually of irregular shape; the second type is moderately wide, relatively long and more regular in shape; while the third type is deep, narrow and often comparatively straight for some miles. Large scale examples of the first type are the valleys: south to southeast of Lake Placid; around Saranac lake; in the vicinity of Newcomb; from Blue Mountain lake eastward to Rock lake; the region around Indian Lake village; and in the vicinity of Lake Pleasant. These are all some miles across. Large valleys of this sort owe their origin almost entirely to the removal of irregular masses of relatively weak rock by weathering and erosion. Many smaller open valleys of irregular shape have also been produced in this manner. The open, more regular valleys belonging to the second type are confined chiefly to the southeastern half of the Adirondacks, most of them having resulted from the settling of earth-blocks along or between lines of fracture (faults). Excellent examples are the valleys in part occupied by Piseco, Indian and Schroon lakes, and also the remarkable valley at Wells (Hamilton county) which is a wedge-shaped block of earth, several miles long, dropped at least 2000 feet between two earth fractures (see figure 9 and explanation on a succeeding page). There are, to be sure, occasional valleys of this second type which have been produced by ordinary erosion instead of by faulting. The deep, narrow, relatively straight valleys of the third type have resulted for most part in either of two ways, namely, by ordinary erosion where certain streams have been favorably situated as regards volume and velocity of water, or by stream erosion along zones of hard or soft rocks which have

Plate I



PLATE I

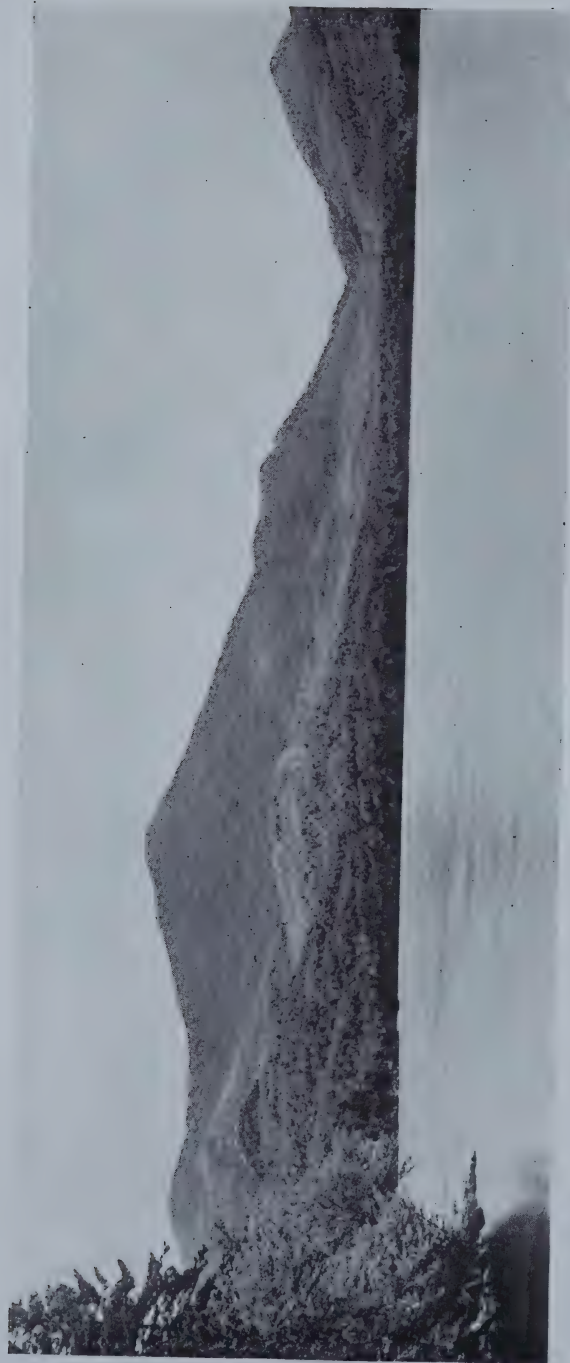
General view of the highest mountain group in the Adirondacks as seen from the Lake Placid Club grounds near Lake Placid village. Mt Marcy toward the left and Mt McIntyre at the right.

Courtesy of Melvil Dewey of the Lake Placid Club

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Plate 2

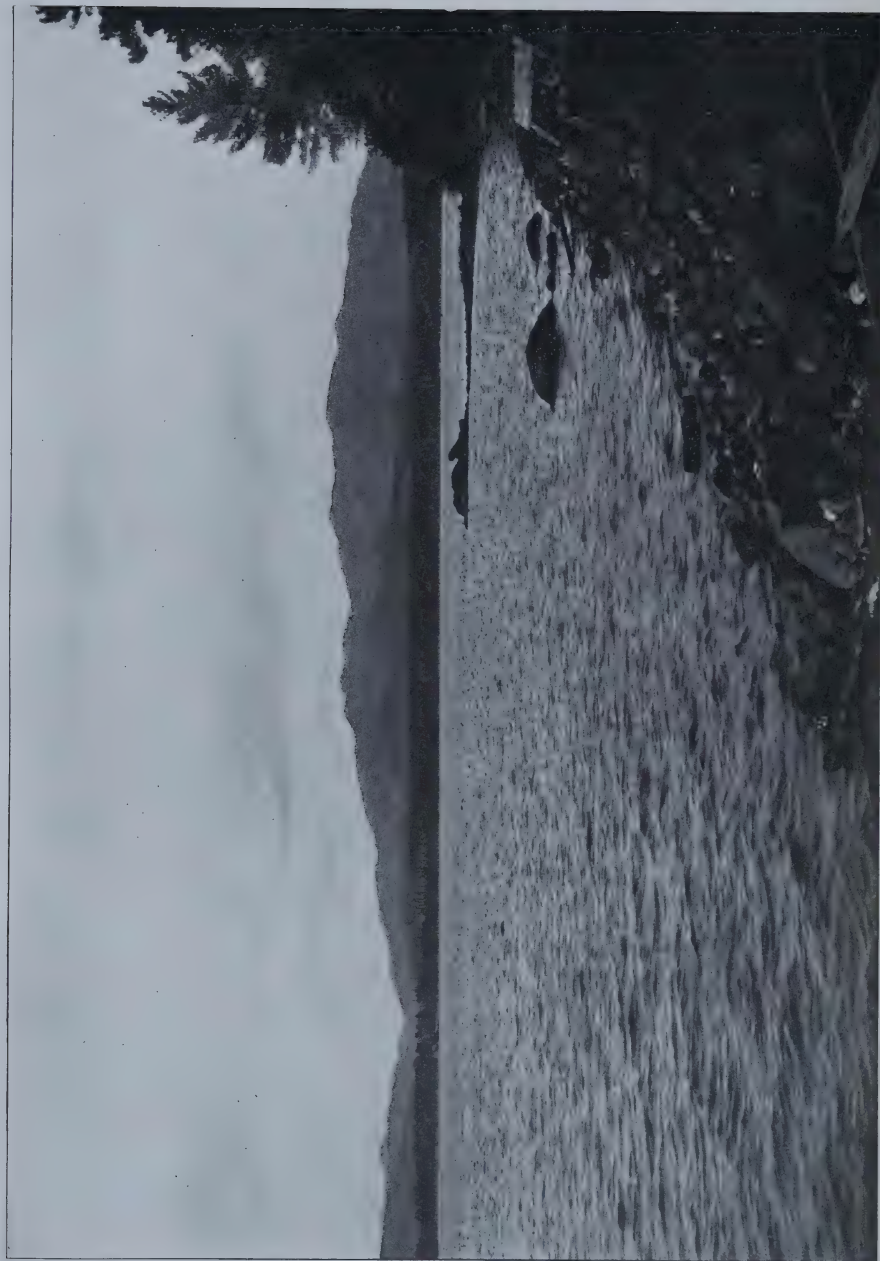


Mt Whiteface as seen from Lake Placid. Sunrise mountain on the right.
Courtesy of the New York Central Lines

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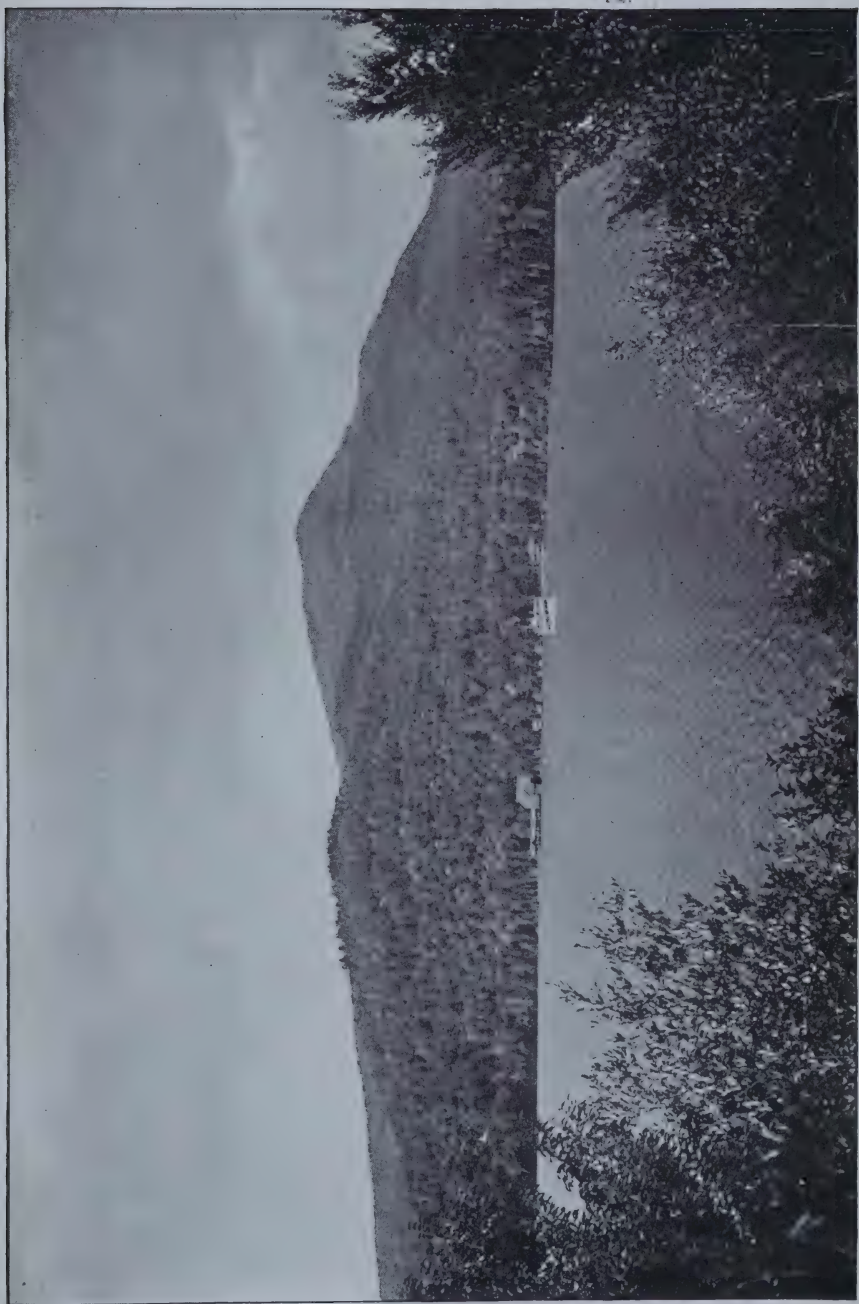


Photo by E. E. Kellogg, Blue Mountain Lake, N. Y.
Blue mountain (altitude 3759 feet) as seen from the southwest across the southeastern arm of Blue Mountain lake

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been notably weakened by having been badly broken or crushed due to earth movements along fractures (faults). These fault-zone, stream-cut valleys are of course wholly confined to the southeastern half of the Adirondacks, and they have been produced by both small and large streams. A few examples are: the Wilmington notch of the Lake Placid quadrangle; Cascade lakes, Ausable lakes and Avalanche Lake valleys of the Mount Marcy quadrangle, Indian pass of the Santanoni quadrangle; two valleys between mountains in the northern half of the Schroon Lake quadrangle; Squaw Brook valley of the Indian Lake quadrangle; and the valley of the Sacandaga river just south of Wells in the Lake Pleasant quadrangle. These fault-zone valleys are usually very narrow with high, nearly precipitous, rock walls on either side. They mostly trend north-northeast by south-southwest in harmony with the faults. Deep, narrow valleys produced by stream erosion without faulting are very common in the Adirondacks. In some cases such valleys are locally gorgelike, due to the fact that the stream courses have been changed since the great Ice Age and the channels have been cut down so rapidly that widening at the top due to weathering has not yet been very effective. Among many such recently formed gorges are the Ausable chasm of Clinton county cut in sandstone; the gorge of the Hudson river cut in hard rock near Stony Creek station in Warren county; and the gorge of the West branch of the Sacandaga river in the western part of the Lake Pleasant quadrangle. These gorges are seldom as straight as the deep, narrow channels cut out along fault zones.

Streams

Viewed broadly, the Adirondack drainage passes outward in all directions from the central portion of the region. The waters from fully two-thirds of the whole mountain area ultimately reach the St Lawrence valley, while the waters from the remaining one-third of the region passes into the Hudson valley (see map figure 4). Inspection of the drainage map shows that a prominent division of drainage (watershed) crosses the Adirondack district irregularly in a north-northeast by south-southwest direction, dividing the region into two roughly equal parts. On one side nearly all the streams flow northwestward to westward from this great divide, while on the other side they flow eastward to southeastward from it. The north, south and southwest-flowing streams out of the Adirondacks are relatively of minor importance. In part this drainage divide

nearly coincides with the main axis of elevation already described, though at two places it lies notably farther to the west.

Fully one-third of the Adirondack area, comprising all the southeastern portion except that around Lake George, passes either directly into the Hudson river or indirectly by the way of the Mohawk river. The Hudson river, with its two large tributaries, the Schroon and the Sacandaga, catches by far most of this water, while East and West Canada creeks, tributaries of the Mohawk, catch most of the remainder. The Hudson proper follows a remarkable course. With sources on the southwestern slope of Mount Marcy, the river, after flowing south for about 15 miles, turns abruptly westward for several miles where it takes the drainage from the chain of lakes in the vicinity of Newcomb. Thence the river turns sharply to the south-southwest for 10 miles along a remarkably straight channel whose position has been determined by a prominent zone of fracture in the earth. Then, after the junction with Indian river, there is a very sharp swing to the east for 8 miles; thence south for 4 miles; and thence in a general south-eastward direction for 25 miles to near Warrensburg. From the mouth of Indian river to near Warrensburg, the course is largely determined by belts of weak rock (limestone) and earth fractures. Instead of passing southeast into the Lake George depression through one of the two low valleys near Warrensburg, both the Hudson and Schroon rivers keep to the west and, after their junction, flow south to Corinth (Saratoga county) on the way passing through a gorge a thousand feet deep; cut in hard rock near Stony Creek station. From Corinth, instead of flowing south through a broad, low valley, the Hudson turns abruptly through a deep gorge in hard rock across a mountain ridge finally to emerge upon the sandy plain near Glens Falls.

Though shorter, the course of the Sacandaga river is no less remarkable. Beginning at the source of the West branch in the southern part of the Lake Pleasant quadrangle, the water flows southwest, west, north, northeast and east where, after making an almost complete circuit of 28 miles, the river is less than 4 miles from its starting point (see map figure 3). This peculiar course is largely due to the arrangement of fracture zones of weakness in the rocks. A few miles more to the east, the East and West branches are confluent. Thence for 18 miles southeast to Northampton in the Broadalbin quadrangle, the direction of the main river is quite normal for this part of the Adirondacks. At Northampton the river shows a remarkable tendency to double back on its course,

changing abruptly from a southeast to a northeast course. Instead of following the broad, low valley southward from Northampton, this northeast course of the river takes it across a ridge of hard rock at Conklingville and into the Hudson at Luzerne. The comparatively straight course of the East Branch Sacandaga has, for at least 12 or 15 miles, been determined along a fracture zone of weakness. The peculiar courses of both the Hudson and Sacandaga near the border of the Adirondacks will be explained in the succeeding chapter.

West Canada creek formerly continued its southwest course into the Mohawk valley, but was forced to turn sharply to the southeast from Trenton Falls because of a blockade of glacial *débris* accumulated there during the Ice Age.

About one-fourth of the Adirondacks, comprising the northeastern portion together with the vicinity of Lake George, drains into Lake Champlain. Before the great Ice Age, Lake George did not exist but there was a division of drainage between the Hudson and Champlain valleys where the "Narrows" are now located. Most of the streams entering Lake Champlain are east-flowing and relatively short and swift. Two notable exceptions are the Saranac and Ausable rivers.

The main branch of the Saranac begins in the large chain of Saranac lakes and pursues a northeast course straight across the main axis of elevation of this part of the Adirondacks. The north branch of the Saranac also cuts across the main axis of elevation. Prominent earth fractures have probably been influential in determining these courses, though the region has not yet been carefully studied.

Both the East and West branches of the Ausable river have courses largely determined along fault or fracture zones of weakness, the deep gorge of the West branch, known as the Wilmington notch, being a notable example of such influence. The main river flows through the famous Ausable chasm near its mouth, this feature being explained toward the end of the next chapter.

About one-third of the Adirondacks drains directly into the St. Lawrence river by many large streams which pursue normal northwesterly courses from the prominent division of drainage across the region. Among the more important streams are the Chateaugay, Salmon, St Regis, Raquette, Grasse, Oswegatchie and Indian rivers. After emerging upon the lowlands of the St. Lawrence valley, most of these rivers exhibit a remarkable tendency to swing northeastward and flow nearly parallel to the great river for some miles

before entering it. These abnormal courses are doubtless due to either ice erosion or accumulation of glacial *débris* during the Ice Age.

Greatest of all the northwestward-flowing streams is the Raquette river. After a devious course of over 100 miles, including passage through several large lakes, the river enters the St Lawrence at the international boundary. The principal source of the Raquette river is Blue Mountain lake in the heart of the Adirondacks. This water flows westward about 8 miles by way of Eagle and Utowana lakes and Marion river into the large irregular Raquette lake. Thence the course changes abruptly northeastward through Forked lake and over cascades into Long lake. After flowing nearly 14 miles through this long, narrow body of water, which is only a comparatively recent enlargement of the stream, Raquette river flows sluggishly northward for 5 miles through a wide swampy valley to Raquette falls where the water descends 75 feet in a gorge three-fourths of a mile long. From Raquette falls the general course of the river is north and west, with sluggish current and many loops (oxbows), through a wide, swampy valley into Big Tupper lake. From Tupper lake the river pursues a quite normal course with considerable velocity into the St Lawrence valley. The history of the upper Raquette river drainage basin is discussed in the next chapter.

Oswegatchie river has its sources in and around Cranberry lake, one of the largest bodies of water in the Adirondacks. The river doubles back on its course in a most remarkable manner a few miles west of Gouverneur.

Approximately one-sixth of the Adirondack drainage passes westward into Black river and thence into Lake Ontario. This drainage is, in most respects, quite normal. The largest stream is Moose river with its several branches, the main or South branch rising in the southern Adirondacks, the Middle branch draining the Fulton chain of lakes, and the North branch draining Big Moose lake. Next most important is Beaver river, which has its sources in and around the Red Horse chain of lakes.

Lakes

Including all, from the smallest to the largest, there are probably no less than 2000 lakes and ponds in the Adirondack region. A few only of the more prominent ones are shown on map figure 3. Considering the beautiful setting of the lakes among the wild,

Plate 5



General view of Lake Placid, looking southward from the summit of Eagle Eyrie
Photo by I. L. Stedman, Lake Placid, N. Y.

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Plate 6



Courtesy of the New York Central Lines
A view across Lower Saranac lake in the northern Adirondacks

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densely forested mountains, this is perhaps the most picturesque lake region of eastern North America. Along the shores of all the larger lakes there are many summer homes and hotels ranging from very moderate cottages and boarding houses to magnificent homes and hotels. Most famous of all are Lake George and Lake Placid. Practically none of the lakes were in existence before the Ice Age.

As regards shape, there are several distinct types of Adirondack lakes. One type, which may be called linear, is long, narrow and straight. Such lakes occupy what were stream channels before the Ice Age. Examples are Lake George, Schroon lake, Indian lake and Long lake. Another type has an exceedingly irregular shore line. Lakes of this sort occupy what were, before the Ice Age, broad, relatively flat valleys or, more exactly, two or more adjacent valleys separated by only low divides, the waters backing up into the side valleys and leaving rock islands and peninsulas. Good examples of this type are Lower Saranac lake, Cranberry lake and Raquette lake. A third type is comparatively round, many of the ponds and smaller lakes especially belonging to this category. The origin of the various types of lakes will be discussed toward the close of the next chapter.

Though the numerous lakes are scattered throughout the Adirondacks, there are, nevertheless, certain more or less well-defined lake belts or groups. Most conspicuous of all is the great lake belt or district some 60 miles long and 10 to 20 miles wide extending northeast by southwest from Lake Placid and the St Regis Lakes on the north to the Fulton chain of lakes on the south. This lake belt lies almost wholly west of the main axis of elevation through the Adirondacks. Not only are lakes and ponds notably more abundant in this district than elsewhere, but also here are to be found many of the larger and better known lakes as, for example, Lake Placid, the St Regis lakes, the Saranac lakes, Big and Little Tupper lakes, Long lake, Blue Mountain lake, Raquette lake, and the Fulton chain of lakes. Most numerous of all are the lakes and ponds in the Saranac-St Regis Lakes district, there being something like 150 within the 214 square miles of the St Regis quadrangle alone. By far most of the lakes of the great belt lie between 1500 and 2000 feet above sea level. Only a few of the most prominent ones will be briefly described here, the problem of the origin and destruction of the lakes being mainly reserved for discussion in the next chapter.

Lake Placid is by many regarded as the most beautiful sheet of water in the Adirondacks. It is 4 miles long, 1 to 1½ miles wide and at an altitude of 1859 feet. Mountains from 1000 to 3000 feet high rise from its shores on all sides except the south. Mt Whiteface stands out majestically more than 3000 feet above the waters of Lake Placid on its northeastern side. There are three rock islands, two of them large and densely wooded, rising several hundred feet out of the lake.

Upper and Lower Saranac lakes are 7½ and 5 miles long, and 1571 and 1534 feet above sea level, respectively. They lie in a much larger and more open valley than Lake Placid with surrounding mountains not nearly so high, the highest being from 1500 to 2000 feet above the lakes on the east and southeast. Lower Saranac lake is full of rock islands.

Big Tupper lake, 7 miles long and about 1 mile wide, lies in a narrow valley with hills only a few hundred feet high immediately surrounding it. Its surface is 1542 feet above the sea. There is a string of rock islands through the middle of the lake.

Long lake, in the very heart of the Adirondacks, is the most remarkable linear type of lake in the whole region. With a length of 13½ miles, it is almost perfectly straight and never more than 1 mile wide. Its altitude is 1630 feet and lies in a narrow valley of moderate depth, a few mountains only reaching heights of 1000 to 1700 feet immediately around the lake. It contains a number of islands.

Blue Mountain lake is only 2½ miles long by 1¼ miles wide but has a beautiful setting among the mountains near the center of the Great North Woods. It lies 1789 feet above sea level with Blue mountain towering 2000 feet above its waters on the eastern side. The picturesqueness of this lake is greatly enhanced by the scattering, wooded, rock islands. Immediately on the north and south the mountains are only of moderate height.

Raquette lake has one of the most irregular shore lines of any in the Adirondacks. It is 8 miles long and fully 1 mile wide at several places. Its altitude is 1762 feet. This beautiful sheet of water occupies portions of several old, low valleys. Only two points reach heights of 500 to 700 feet around the sides of the lake, but the picturesque islands and numerous bays and peninsulas add much to the beauty of this large body of water.

The Fulton chain of lakes, eight in all, lie in a moderately deep narrow valley on the southwestern slope of the Adirondacks.

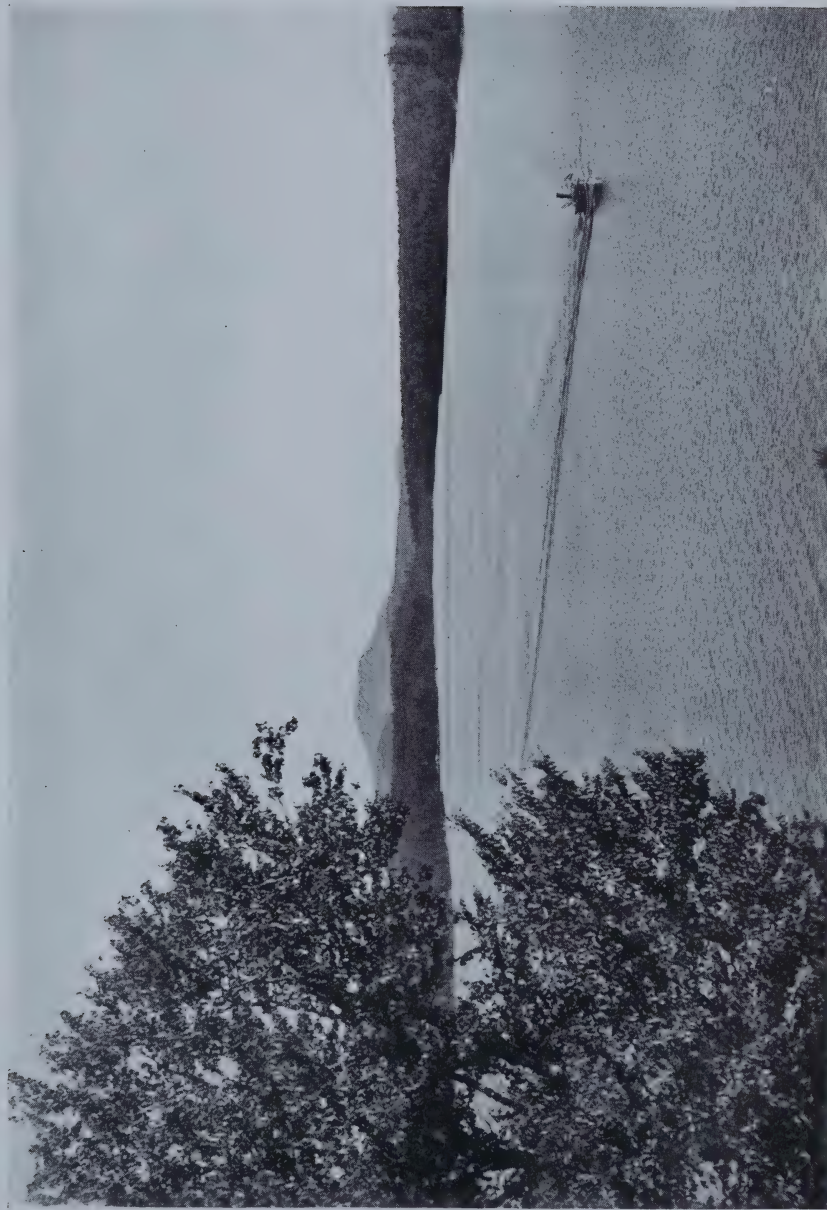
Plate 7



W. J. Miller, photo
View looking west across Blue Mountain lake. Eagle and Utowana lakes partially visible in the distance.

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A view across Raquette lake

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Photo by F. N. Kuceland, Northampton, Mass.
Part of the Fulton Chain of Lakes, viewed from the top of Bald mountain

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Courtesy of the Delaware & Hudson Company, and permission of the Detroit Publishing Company
Lower Cascade lake, on the road between Lake Placid and Keene Center, Essex county. Altitude of lake, 2032 feet.
A mountain rises steeply 1500 feet on the north side and 2000 feet on the south side.



Fourth lake is the largest, being $5\frac{1}{2}$ miles long, $\frac{1}{2}$ to 1 mile wide and 1707 feet above the sea.

Cranberry lake lies in the northwestern Adirondacks and to the west of the great lake belt just described. This is one of the very largest bodies of water in the whole mountain region, having a length of 9 miles, greatest width of 3 miles and an exceedingly irregular shore line. Like Raquette lake, this sheet of water appears to occupy portions of several old valleys. The surface of the lake is 1540 feet above the sea, and hills rise 500 to 1000 feet around it.

On the northeastern border of the Adirondacks, but in a sense forming a northward continuation of the great lake belt, is a group of three considerable lakes, namely, Lower and Upper Chateaugay lakes and Chazy lake at altitudes of from 1300 to 1500 feet. The immediately surrounding country is fairly rugged and mountainous.

Avalanche lake, though small and outside the great lake belt, deserves special mention. It is really only a large pond, nearly one-half of a mile long and very narrow, lying in one of the deepest and perhaps most romantic notches in the whole Adirondack region. It is situated 2863 feet above sea level at the western base of Mt Colden (Essex county). Great rock walls rise from the water's edge on either side, almost perpendicularly to a height of 1000 feet on the west and on the east very steeply to a height of nearly 2000 feet or to the summit of Mt Colden. At one place there is not even room for a mountain trail along the lake.

A minor lake belt lies immediately east of the main axis of elevation in the south-central Adirondacks, the principal lakes being Indian, Pleasant, Sacandaga and Piseco. Indian lake is very distinctly of the linear type, though forked toward the south. It has a length of 13 miles, greatest width of 1 mile and an altitude of 1650 feet. It occupies a deep narrow valley with mountains on the west side rising from 1000 to 2000 feet above its waters, and on the east side from 500 to 1000 feet. It should be stated that the present size of Indian lake is much greater than the natural lake which formerly occupied this basin because of the state dam at the north end.

Sacandaga lake and Lake Pleasant are close together at the same altitude (1724 feet) and joined by a narrow channel three-fourths of a mile long. They occupy portions of a broad, irregular valley with mountains on all sides rising from a few hundred to a thousand feet or more. Sacandaga lake is of irregular shape about

2 miles across. Lake Pleasant is over 3 miles long and from one-half to 1 mile wide.

Piseco lake is of the linear type with a length of 5 miles and an average width of 1 mile. It lies 1661 feet above sea level. On its eastern side there are low hills only, but a long mountain mass rises abruptly from 600 to 1100 feet above its western shore.

Another group of lakes occupies the southeastern border of the Adirondacks, the principal bodies of water being Lake George, Schroon lake and Brant lake. These are all notably nearer sea level than the usual Adirondack lakes.

Lake George is the most remarkable body of water in the entire Adirondack region. It has a length of 32 miles and a width of from 1 to $2\frac{1}{2}$ miles, so it is easily the largest of all the northern New York lakes. The surface of the lake is only 323 feet above the level of the sea, thus making it one of the very lowest bodies of water in the whole Adirondack region. The valley, or rather combination of two valleys (see page 64), occupied by Lake George is remarkably straight, deep and narrow. For most part mountains rise abruptly from a few hundred to over 2000 feet above the shores of the lake throughout its length. Where the lake is narrowest, for 6 or 8 miles of its middle portion, the scenery is grandest. On the eastern side the Black-Erebus mountain mass rises very steeply 2000 feet or more from the very shore of the lake, while on the western side the Tongue-Fivemile mountain mass rises very abruptly 800 to 1600 feet. There are many islands, especially in the narrow portion, thus greatly enhancing the scenic effect.

Schroon lake is the second largest in the southeastern Adirondacks. It also is of the linear type, being 9 miles long and from one-half to $1\frac{1}{2}$ miles wide. It lies only 807 feet above sea level. There are no high mountains immediately around the lake, the highest hills being on the eastern side where they rise only 400 to 600 feet.

Brant lake is a beautiful sheet of water nearly 5 miles long, one-half to three-quarters of a mile wide and 801 feet above sea level. It is almost completely surrounded by hills from 200 to 800 feet high.



Lower Ausable lake, a few miles east of Mt Marcy, Essex county. Mountains rise very steeply 2000 feet above the lake from the very water's edge. Altitude of lake, 1961 feet. Mt Colvin, altitude 4074 feet, plainly seen.

Courtesy of the Delaware & Hudson Company

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Photo loaned by John A. Cole

View across Sacandaga lake in Hamilton county, looking north from the top of Lookout mountain

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Plate 13



General view of Lake George, looking northward from Shelving Rock. Tongue mountain in the center; the main part of the lake in the foreground and on the right; and Northwest bay on the left.

Courtesy of the Delaware & Hudson Company

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View looking southward through the narrows of Schroon lake

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PHYSICAL HISTORY OF THE ADIRONDACKS

Prepaleozoic History

The most ancient (Grenville) rocks and history. The Adirondack mountains are made up almost entirely of exceedingly old rocks. Of these the most ancient known are called the *Grenville* series, so named from a Canadian town in the St Lawrence valley. Not only are the very earliest known records of the history of northern New York written in these Grenville rocks, but also they are to be classed with the very oldest recognized rock formations of the earth. Only during the past 25 years has the real significance of the Grenville and closely associated rocks in the Adirondacks been discovered.

The Grenville consists of a great series of sediments — original muds, sands and limes — which were deposited layer upon layer under water. The widespread extent of the series, far beyond the limits of the Adirondacks, and their great thickness make it certain that the Grenville sediments were accumulated on the bottom of a relatively shallow ocean very much as sediments are now piling up on the marginal sea bottom. Thus, the most ancient known geographic condition of the Adirondack district was an expanse of sea water covering the whole area.

It may occur to the reader to ask: How long ago did the Grenville ocean exist? There are grave difficulties in the way of answering this question in terms of years since we have nothing like an exact standard for such a measurement or comparison. Although we must concede that not even approximate figures can be given, nevertheless it can be demonstrated by several independent lines of reasoning that the time must be measured by at least some tens of millions of years, very conservative estimates ranging from 25 to 50 million years. In any case, the time is utterly inconceivable to us, the important thing to bear in mind being that the great well-known events of earth history which have transpired since the existence of the Grenville ocean require a lapse of many millions of years as shown by the enormous accumulations of sediment in many parts of the earth and the repeated revolutionary changes in geographic and geologic conditions. The ideas here expressed will be much better appreciated by the reader after following through the story of the Adirondacks as set forth in the succeeding pages. By so doing, it is hoped that the reader will not only learn the main

events in the history of the Adirondacks, but also gain an understanding of some of the fundamental methods and principles of earth science (geology).

The exact placing of the very ancient Adirondack rocks in the geologic time-table (see page 12) is a difficult matter, through the Grenville series is, in the light of the strongest evidence, to be classed with the Archeozoic or oldest known rock group. For the younger Adirondack rocks (below discussed) which are so closely

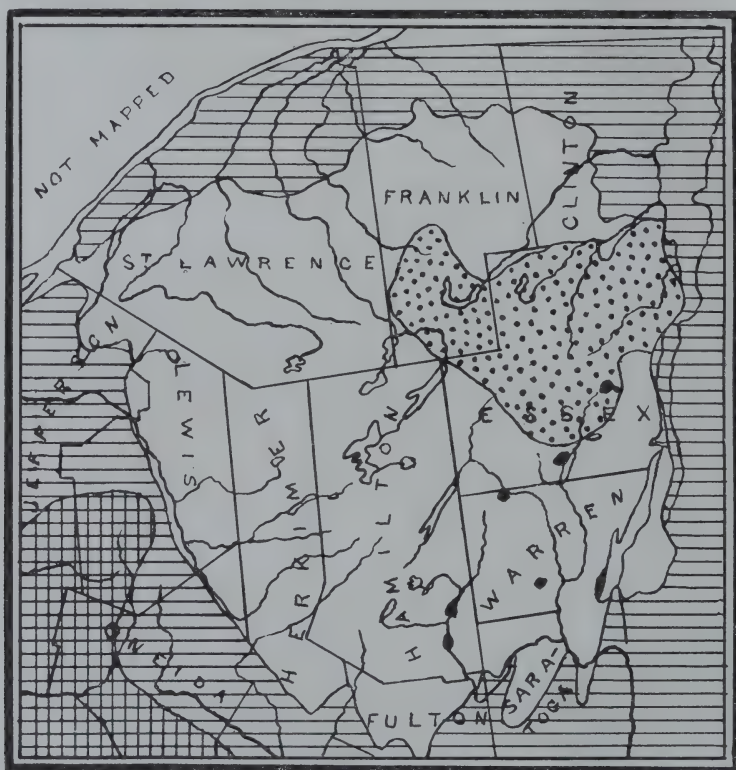


FIG. 5 Generalized geologic map of northern New York showing the distribution of the principal rock systems. Unshaded portion: Prepaleozoic rocks, chiefly Grenville strata, syenite, and granite; dotted portion: Prepaleozoic rock, chiefly anorthosite; horizontal-lined areas: Cambrian and Ordovician strata; cross-lined area: Silurian strata; small black patches: isolated areas of Paleozoic strata.

associated with the Grenville, the evidence is not so clear. They may be partly Archeozoic and partly Proterozoic or they may be wholly Proterozoic. In any case we are certain that they are all earlier than the Paleozoic because very early Paleozoic strata rest upon them around most of the borders of the Adirondacks.

The Grenville strata, as we see them today, do not look like ordinary sediments such as shales, sandstones and limestones. They have been profoundly changed from their original condition; that is to say, they have undergone *metamorphism*. The Grenville rocks now exposed to view were formerly buried at least some miles below the earth's surface, the overlying rocks having been removed by erosion through millions of years of time. Far below the earth's surface, under conditions of relatively high temperature, pressure and moisture, the materials of the Grenville strata completely crystallized into various minerals. Rounded, water-worn grains of the original sediments no longer exist, but instead angular grains (crystals) make up the rocks. The original stratification surfaces (that is, surfaces of separation of the layers of sediment) are almost always still present. Many times this stratification is very clearly evident where lighter and darker colored layers from a fraction of an inch to several inches or feet wide sharply alternate. This well-defined banded structure is one of the most useful criteria for the recognition of the stratified character of the Grenville rocks. The other Adirondack rocks are all igneous in origin; that is, they were once molten, and are much more homogeneous throughout large masses, or if they show variation they are never in sharply defined layers.

Careful examination of Grenville specimens frequently shows that the mineral grains are more or less flattened out parallel to the stratification surfaces. Because of the parallelism of flattened minerals and stratification, and because the Grenville series has never been subjected to severe mountain-making pressure (see below), we are forced to conclude that the mineral flattening took place during the crystallization of the sediments far below the earth's surface under great weight of overlying material and when the strata were still in practically horizontal position. Such mineral flattening would of course have taken place at right angles to the direction of pressure.

Having established the sedimentary origin of the Grenville series, we are led to the interesting and important conclusion that these oldest known rocks are not the most ancient which ever existed in the Adirondack region. The Grenville sediments must have been deposited, layer upon layer, upon a surface of still older rocks. A knowledge of the character and composition of such pre-Grenville rocks would be of very great interest, but thus far we have no positive evidence that such rocks are visible in the Adirondacks, although certain masses still of somewhat doubtful age and origin

may belong to that very ancient rock floor. Again, the fact that Grenville sediments were being deposited under water carries with it the corollary that there must have been land somewhere at no great distance from the area of deposition because, then as now such sediments as muds and sands could have been derived only from the erosion or wear of land and have been deposited in layers under water adjacent to the land mass. Here too we are as yet utterly in the dark regarding any knowledge of the location or character of that very ancient land.

Perhaps the most interesting and characteristic of the Grenville rocks is the *crystalline limestone* or *marble*. It is widely scattered in small to large areas throughout the Adirondacks. Typically it is a white, coarse-grained, granular rock made up almost entirely of crystals of calcite.¹ When exposed to the weather it often crumbles to a gravelly looking mass. Layers of dark or greenish rocks often occur within the limestone, these representing what were originally layers of sea mud interstratified with the lime. Black, shiny flakes of graphite (so-called "black lead") may nearly always be found in the limestone, while quartz grains several millimeters across are often abundant in certain portions of the limestone formation. This limestone could not possibly have been of other than sedimentary origin.

In numerous places, and sometimes in sharp contact with the limestone, are beds of almost pure quartz rock or so-called *quartzite*. Such rock is a crystallized, metamorphosed sandstone and could not possibly have been of igneous origin. This quartzite is generally in thin layers of clear flintlike or glassy appearance and with perfect stratification. Sometimes other minerals, especially white mica (muscovite), are mixed with the quartz.

Most abundant of all the Grenville rocks, however, are very extensive, thick deposits of usually dark to light gray rocks rich in such minerals as quartz, feldspar, garnet, mica, pyroxene and amphibole. Because of their distinct banded (stratified) structure and close association (often interbanded) with the limestone and quartzite, they are also certainly ancient sediments, in this case original sea muds or less admixed with sand and lime. As a result of heat, pressure and moisture, these sea muds have been crystallized into what are now called *schists* or *gneisses* (see page 10). Certain of the quartzites, schists and gneisses also at times contain scattering flakes of graphite ("black lead"), in some cases

¹ See appendix for descriptions of common Adirondack minerals.

Plate 15



W. J. Miller, photo

Tilted and clearly stratified Grenville rock (various gneisses) on
Chimney mountain, Hamilton county

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there being a sufficient content of this mineral to warrant its mining, as in Warren and Saratoga counties.

As will be explained shortly, the Grenville strata are associated with younger rocks of pre-Paleozoic age, these later rocks all being of igneous origin and having cut through the Grenville in hundreds of places and in a most irregular manner, so that the ancient strata are not now present as a single continuous mass of rock occupying the whole Adirondack region. A detailed map of the whole mountain area showing the distribution of the Grenville and later rocks would present a decided "patchwork" effect. Portions only of the region have been thus mapped in detail; the writer's geologic maps of the North Creek, Lake Pleasant and Blue Mountain quadrangles recently published by the New York State Museum afford excellent illustrations of the "patchy" distribution of the Grenville strata. Figure 9 of this volume also suggests the same thing.

Since the strata of the Adirondacks are usually badly disturbed, tilted and more or less bent or folded, and since neither top nor bottom of the formation has ever been recognized as such, it is impossible to give anything like an exact figure for the thickness of the Grenville rocks. Continuous successions of strata have been observed in enough places, however, to make it certain that the strata were piled, one layer upon another, to a thickness of many thousands of feet. Across a certain valley in Warren county the writer has seen fully 20,000 feet of Grenville strata piled up and only moderately tilted. This clearly implies that the Grenville ocean existed for a vast length of time which must be measured by no less than a few million years, because, in the light of all our knowledge regarding the rate of deposition of sediments, such a very long time was necessary for the accumulation of so thick a mass of sedimentary rocks. It does not necessarily follow that the Grenville ocean was thousands of feet deep when the deposition began. In fact, the very character of the sediments clearly indicates that the Grenville ocean was, for most part at least, of shallow water, for such sediments as sands and muds have rarely if ever been carried far out into an ocean of deep water. The great ocean abysses of today are not receiving any appreciable amount of land-derived sediments. Hence it is practically certain that the very ancient Grenville sea bottom gradually sank as the sediments accumulated. Similar phenomena are definitely known to have occurred in many later basins of deposition.

There is no evidence whatever for the existence of land life of any kind during this very early era of earth history. Regarding

life in the Grenville ocean, however, we are certain that organisms of some kind must have existed as proved by the scattering flakes of graphite through many of the strata, especially the limestone. All that is now left of the organisms is the carbon, and this has been crystallized into graphite so that no original structures whatever are retained. Even though we do not know whether these organisms were plant or animal, the fact that life existed on our planet so many millions of years ago is a fact of very great importance. When we look at the shiny black scales of graphite in a piece of Grenville rock, we can truthfully say that we are gazing upon vestiges of the earliest known organisms which ever lived upon the earth. Graphite thus disseminated through stratified rocks must have been of organic origin. Anthracite coal, which is chemically very similar to graphite, occurs in the late Paleozoic strata of Pennsylvania and is there definitely known to have been derived from plants through the process of carbonization. Graphitic anthracite of like origin occurs in Rhode Island. The earth's first organisms must have been plants, because animals ultimately depend upon plants for their existence. The oldest known clearly preserved fossils are Algae or sea weeds from the Proterozoic. Hence it seems likely that the graphite of the Grenville strata represents the remains of plants, probably of the simple sea-weed type. This by no means proves the absence of animals from the Grenville ocean, because animals with soft parts only would have left no record, while shells would have been destroyed by solution and crystallization under the conditions to which the strata were subjected.

Earliest igneous rocks and their history. After the accumulation of the Grenville sediments, igneous activity took place on grand scales, when great masses of molten rock were forced (intruded) into the sediments from below. At least two distinct times of very early, large scale igneous activity have been discovered. The general effect was to break the Grenville up into patches. The present distribution and mode of occurrence of these igneous rocks show that the molten masses broke into the Grenville strata in a very irregular manner. In most cases the Grenville rocks were pushed aside by, or tilted or domed over, the upwelling molten floods; in many cases the molten materials under great pressure were intimately shot through the Grenville strata; often large or small masses of strata were caught up or enveloped (as inclusions) in the molten floods; in some cases there appears to have been actual local melting or assimilation of Grenville rocks by the molten intrusions; while in still other places large Grenville bodies

have apparently been left intact and undisturbed. These igneous rocks are all of the plutonic type; that is, they were never forced up to the earth's surface but solidified at considerable depths below the surface. We see them exposed today only because a tremendous amount of overlying material has been removed by erosion. These igneous rocks are generally easily distinguished from the old sediments of Grenville age because of their more general homogeneity in large masses and their lack of sharply defined bands of varying composition. The fact that the minerals have always crystallized to form medium to coarse grained rocks shows that the rocks solidified under deep-seated conditions, since it is well known that surface flows (lavas) are much finer grained and often with more or less of the rock not crystallized at all. Slow cooling under great pressure favors more complete crystallization and the growth of larger crystals.

The first of the two well-known great intrusions of molten rock in the Adirondacks is represented by the present large area (1200 square miles) of so-called *anorthosite*, mostly in Essex and Franklin counties. The typical rock is very coarse grained, of bluish gray color and consists principally of a feldspar (labradorite). This feldspar is in crystals commonly from one-half of an inch to nearly 2 inches long with shiny cleavage faces when freshly broken, and they often exhibit a pretty play of colors. Fine parallel lines, as though ruled on with a delicate instrument, also very commonly show on the cleavage faces. The typical anorthosite is usually quite homogeneous in large bodies as, for instance, in the Sentinel range a few miles east of Lake Placid, and in the mountains just west of the same lake. An interesting and important variation of the typical rock is known as the Whiteface type of anorthosite, so named from Mt Whiteface, the summit of which is made up of this rock. This is usually white or nearly so, the feldspar crystals having been much broken (granulated) under pressure. Another variation is a darker rock due to a considerable percentage of black minerals, especially pyroxene, amphibole and iron ore. This darker rock is often rather streaked in appearance, the minerals having been drawn out into crude parallelism due, no doubt, to movements or currents in the molten masses just before they congealed. This variety of anorthosite is only locally developed, especially around the borders of large bodies of the typical anorthosite. Many of the highest mountains of the east-central Adirondacks, such as Marcy, McIntyre and Whiteface, consist wholly or largely of anorthosite. The anorthosite intrusion differed from the later intrusions

(below described) in two important respects, namely, that it was practically confined to a single great area of 1200 square miles, and that it broke through the Grenville only, no other country rock having been present at the time of the intrusion. A few small masses of anorthosite are known to occur outside of the great area as, for example, in the central part of the Long Lake quadrangle; northern part of the Blue Mountain quadrangle; northeastern part of the Lake Pleasant quadrangle; and near Rand Hill in Clinton county. For most part the molten anorthosite appears to have pushed aside or displaced the Grenville, though in many cases small areas and fragments are seen enveloped by the intrusive, while in a few cases there appears to have been injection or possibly assimilation of the Grenville. That this anorthosite is younger than the Grenville is demonstrated by the facts that tongues of the rock have been observed cutting through the Grenville (see figure 6), and also that fragments of the old strata are frequently seen to have been torn off and completely enveloped in the molten anorthosite.

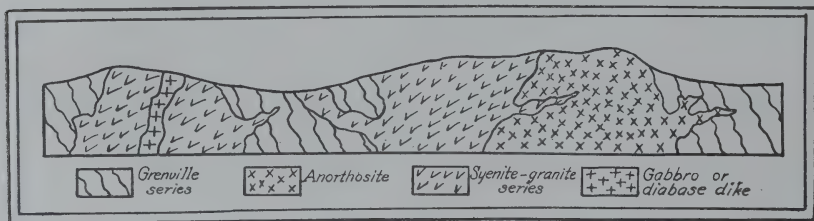


FIG. 6 Generalized section showing how the relative ages of the most common Adirondack rocks are determined. Where one rock mass cuts through the other, the former is the younger. (By W. J. M.)

The next clearly recorded event after the intrusion of the anorthosite was very widespread igneous activity when the rock known as the *syenite-granite* series, so common in the Adirondacks, was forced upward in a molten condition into both the Grenville and the anorthosite. There may have been more than one time of intrusion, as argued by certain workers for the St Lawrence valley, but, for our purpose, it will suffice to regard all the syenite-granite rocks to have been intruded at practically the same time, since the sum total of effects is much the same as though there had been only a single period of igneous activity. All portions of the Adirondacks felt the force of the intrusion of these molten masses which are now represented by numerous large and small areas very irregularly scattered throughout the region. Almost all the higher mountains outside of the anorthosite area consist of syenite or

granite, because these rocks have been much more resistant to weathering and erosion than the ordinary Grenville strata which latter, therefore, generally occupy the valleys.

The *granite* is a plutonic igneous rock which consists essentially of quartz and feldspar (orthoclase), but which usually also contains more or less black mica (biotite), amphibole, pyroxene and magnetite. The *syenite* is similar, except that quartz is either absent or much less prominent. Mostly, if not always, these two rocks are merely variations of the great molten masses formed during the cooling and crystallization of the rock. Accordingly it is a very common thing to observe granite and syenite grading back and forth into each other often within short distances, instead of one cutting through the other as would be the case if one were younger than the other. The typical syenite and granite are medium grained, that is, they are made up of mineral crystals a few millimeters across. Locally the rock may be much coarser grained with feldspar and quartz crystals up to an inch or more long. At times some of the feldspar crystals are decidedly larger than the rest of the minerals, giving rise to rock types known as granite or syenite *porphyry*. Syenite is nearly always richer in dark minerals — black mica, amphibole, pyroxene and magnetite — than the granite. Sometimes these dark minerals make up as much as half of the rock. When freshly broken the typical syenite has a greenish gray color, while the weathered surfaces are light to dark brown due to the fact that the iron of the dark minerals has oxidized (weathered out) to produce the brown stain of iron rust. This weathered portion is seldom more than a few inches thick. Sometimes in the woods on mountain sides, the immediate surface of the syenite is nearly white with a brown layer just below the surface. The explanation is that water charged with decomposing organic matter has dissolved off the iron rust. The freshly broken granite varies from greenish gray to light gray to pinkish or even reddish, the color depending largely upon the color of the feldspar. Dark colors are rare in the granite because of the relative scarcity of dark minerals in the rock.

Except for the gradations above referred to, the syenite and granite are fairly homogeneous in large bodies, there being no sharply defined layers as in the Grenville strata. One feature is, however, important to consider, namely, the wavy or streaked appearance presented by so many of the rock ledges of syenite and granite. A close inspection reveals the fact that most of the minerals have been flattened or drawn out into a sort of crude

parallelism. This structure is accentuated by the dark-colored minerals. A rock with such a structure is said to be a gneiss (pronounced "nice"). Many ledges of Adirondack syenite or granite exhibit this structure perfectly, but in other cases it is very faint or absent. This phenomenon has generally been ascribed to the flattening and flowage of the minerals under great pressure in the earth's crust after the cooling of the rocks. But very recently the writer has presented much evidence in support of the view that the phenomenon really represents a sort of "flow-structure" produced by currents under moderate pressure during the crystallization and when the rocks were at least partially molten. The rapid changes in direction and the sweeping curves exhibited by the gneissic structure strongly support the "flow-structure" idea.

Rocks presenting the characteristics of the syenite and granite are typical plutonic, igneous masses which certainly never reached the surface by intrusion. They were very slowly intruded and slowly cooled under great pressure thousands of feet below the earth's surface. It should be reiterated that rocks of this sort now appear at the surface simply because of vast removal by erosion of the overlying materials.

That these syenite-granite rocks are younger than the anorthosite has been demonstrated by finding tongues of the former cutting or breaking through the latter (see figure 6) as well shown, for example, a few miles east of Tupper Lake village, and on the eastern face of Whiteface mountain.

First known uplift of the Adirondacks. We are now ready to discuss the earliest known uplift of the whole Adirondack region above sea level, or, in other words, the birth of the first known Adirondack mountains. As we have learned, the very character and structure of the rocks now exposed to view in the region show conclusively that they were at one time deeply buried, the inference being perfectly plain that those materials have been removed by erosion. Profound erosion of any land mass means that the land must have been well above sea level, and thus we come to the important conclusion that the great mass of rocks, including Grenville strata, anorthosite and the syenite-granite series, were upraised well above sea level. Just when the uplift occurred can not be positively stated, but there is much evidence favoring the idea that it was concomitant with the great igneous intrusions, especially of the syenite-granite. It is reasonable to believe that the same great force which caused the welling up of so much liquid rock might easily have caused a decided uplift of the whole region. The

Plate 16



Upper view: a typical outcrop of Adirondack syenite in Lewis county

Lower view: dikes of diabase (dark rock) in syenite near Northville, Fulton county

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Grenville strata are now very frequently not in horizontal position as when they were deposited under the sea. On the other hand, there is no known evidence that the Adirondack Grenville strata were ever severely folded or compressed as has been the case in many mountain ranges, as the Appalachians, for example. Many broad belts of Grenville are known to be only very moderately folded to almost horizontal; numerous masses, large and small, are merely tilted or domed; while very locally the strata sometimes are contorted or sharply folded. The structural relations are, therefore, best explained as having been the result of slow, irregular, upwelling of the more or less plastic molten masses, probably under a moderate compressive force or lateral thrust in the crust of the earth, whereby the strata, previously disturbed little or none at all, were simply broken up or tilted or domed. In many places the evidence is perfectly clear that the tilting of the Grenville strata was directly due to the up-push of the intrusive rocks. Locally, where masses of Grenville were caught between two bodies of upwelling molten rock, the strata were sometimes twisted or sharply folded, this having been especially true of the relatively very plastic limestones. It appears to have been literally true that the Grenville strata were irregularly floated on a vast body of molten rock, the latter in many places either having arched up or broken through the strata. In other words, the Grenville strata, as well as the great intrusives, were not subjected to real mountain-making pressure in the crust of the earth whereby the rocks were thrown into a series of great folds, as has happened in many mountain regions of the world.

We can not even state the approximate height of those very ancient Adirondacks. Also we are utterly in the dark as to the character of the topography and the direction of the drainage lines. The fact that thousands of feet of material have been removed by erosion, thus exposing the present rocks to view, does not necessarily imply that the mountains at any time had a very great height because it is possible that, while elevation slowly progressed, material was steadily removed by erosion. All our knowledge of later and better known mountains, however, leaves little doubt but that those ancient Adirondacks were notably higher than those of today.

Later Prepaleozoic history. The profound erosion of the very ancient Adirondacks extended through some millions of years of the later Prepaleozoic and even into very early Paleozoic time, but

the whole problem of this erosion and its significance is discussed a few pages beyond.

At some time after the vast bodies of syenite-granite were thoroughly consolidated, but certainly before the Paleozoic era, there were several relatively minor intrusions of molten rock. These times of intrusion are very distinctly separable and the rocks are of quite different appearance. First of these was the so-called *gabbro*. This rock varies considerably though it is always dark gray to black and usually medium to coarse grained; that is, the mineral constituents range from one or two millimeters to fully an inch in length. Typically the rock contains feldspar (plagioclase), pyroxene, hornblende, black mica (biotite) and magnetite with various other minerals in small amounts. Sometimes the gabbro is difficult to distinguish from certain of the dark border phases of the anorthosite already described, though usually the long, lath-shaped feldspar crystals irregularly inclosing the pyroxene or hornblende characterize the gabbro. Also the mode of occurrence of the gabbro is different from that of the older intrusives. Instead of breaking up, raising up or tilting the country rock, the molten gabbro appears to have penetrated the earth's crust through practically vertical, cylindrical or pipelike openings seldom more than one or two miles in diameter. As seen in the field, the gabbro is a typical plutonic rock with sharp, practically vertical contacts against the older (country) rocks. Sometimes the gabbro exhibits a streaked appearance (gneissoid structure) due to a crudely parallel arrangement of minerals resulting from movements or currents in the still partially molten masses under pressure. These bodies of gabbro are scattered throughout the Adirondack mountains and are well exhibited on most of the published geologic maps (see appendix), fully sixty occurring within the North Creek quadrangle alone.

Another interesting igneous rock, and still later than the gabbro, is the so-called *pegmatite* which is really a sort of very coarse-grained whitish granite. It consists almost wholly of quartz and feldspar in crystals from one-half to several inches across. Usually it contains more or less white mica (muscovite). This rock occurs in the form of dikes, that is, it fills fissures from an inch or two wide and a few yards or rods long to 50 or 75 feet wide and many rods long. Such pegmatite dikes may be seen cutting through all the previously described rocks with very sharp contacts, and hence they are clearly younger. Pegmatite dikes are very common throughout the Adirondacks and they are easily recognized.

The very latest Prepaleozoic rock in the whole Adirondack region is another sort of dike rock known as *diabase*. It is really almost the same as basaltic lava, being fine grained, bluish black where freshly broken and containing chiefly plagioclase feldspar, pyroxene and iron ore (magnetite). It differs from the gabbro in being finer grained and always occurring in sharply defined, narrow, dike or fissure form. These dikes commonly vary from a few inches or feet wide and a few rods long to many feet wide and several miles long. Such dikes are of rather common occurrence throughout the Adirondacks and are very easily recognizable by their black, sharply defined outlines. The fact that they are so fine grained, often even glassy at the borders, shows that they cooled much more quickly and nearer the surface of the earth than any of the other igneous rocks. It seems quite clear, therefore, that the diabase now at the surface was forced into fissures after most of the Prepaleozoic erosion of the region had been accomplished. On the other hand, the intrusions must have taken place before the oldest Paleozoic strata around the Adirondacks were formed because such strata have been observed to rest upon the diabase. In the light of these facts it is safe to say that these latest dike rocks are millions of years younger than the oldest igneous rocks of the Adirondacks.

Paleozoic History

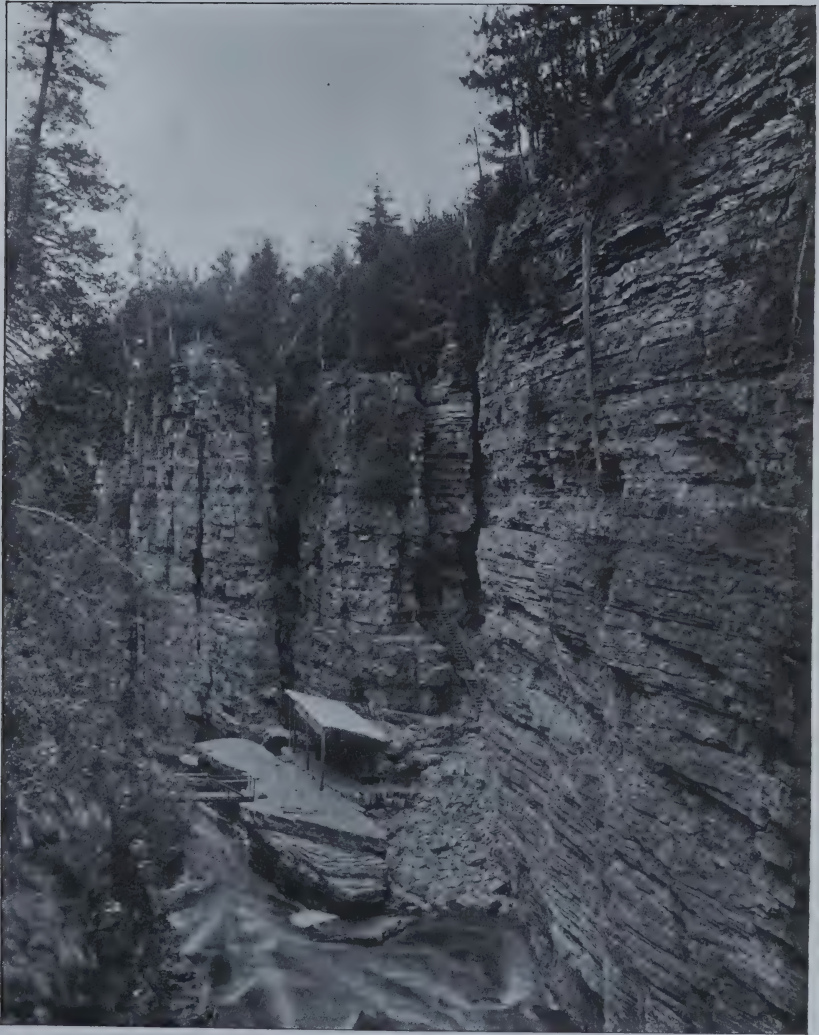
Cambrian period. After the first known Adirondack uplift, the whole region was subjected to profound erosion which began long before the opening of the Paleozoic era. The first period of the Paleozoic era is known as the Cambrian. Since later Cambrian strata rest upon the Prepaleozoic rocks around most of the borders of the Adirondacks, and the earlier Cambrian strata are absent, with no reason to think that they ever were deposited there, we conclude that the time of profound erosion extended into the early Paleozoic or, more strictly, into the later Cambrian. The reader may inquire, Where are the sediments which were derived from the wearing down of the ancient Adirondacks during this vast length of time? Regarding the deposition of the Prepaleozoic sediments we have no certain knowledge. They may have washed westward or southwestward into waters which may possibly have existed there; they may have been carried northward or northwestward into Canada to build up later Prepaleozoic strata there; or they may have been transported eastward toward or into the Atlantic

basin. Regarding the disposal of the early Paleozoic sediments; however, our knowledge is much more certain. Both early and late Cambrian strata are abundantly represented in western New England and to some extent along the central-eastern border of New York, while only late Cambrian strata rest upon the pre-Paleozoic rocks around the borders of the Adirondacks: Also, the late Cambrian strata of northern New York are nearly a thousand feet thick on the northeastern side of the Adirondacks (in Clinton county) and they become thinner southward and westward through the Champlain, Mohawk and St Lawrence valleys, being entirely absent from the southwestern border of the Adirondacks (in the Black River valley). These facts show that the earlier Cambrian sea did not reach into northern New York, but that the later Cambrian sea did extend most, or all, of the way around the Adirondack region, the encroaching waters having come from the northeast as proved by the older and much thicker Cambrian deposits there.

The first deposit to form in this late Cambrian sea is known as the *Potsdam* sandstone which is well represented in the St Lawrence, Champlain and lower Mohawk valleys. These regions were submerged under the Potsdam sea. Not only is the Potsdam sandstone absent from the southwestern border of the Adirondacks, but there is no evidence that it ever was deposited there, hence it appears that that region was dry land during the Potsdam time. In the southeastern Adirondacks the Potsdam sea certainly extended in as far as Wells (in southern Hamilton county) and North River (northwestern Warren county) because small outlying masses of typical Potsdam sandstone occur at those places. These outlying masses were formerly connected with the larger areas but they have become completely isolated by extensive erosion since they were deposited. There is no evidence whatever that the Potsdam sea covered the interior of the Adirondack region. In short, we may say that the ocean of Potsdam time covered all the borders of the Adirondack area except on the southwest and extended well over the southeastern portion.

What do we know about the character of the topography of the land over which that ancient Potsdam sea spread? As a result of the profound erosion, thousands of feet in thickness of material were removed and the whole region must have been well worn down. Was the region worn down to the condition of a peneplain, that is to say, to an area of very low relief near sea level? Recent detailed studies on all sides of the Adirondacks furnish a very satisfactory

Plate 17



Gilbert Van Ingen, photo

A view in the Ausable chasm of Clinton county showing distinctly stratified Potsdam (upper Cambrian) sandstone

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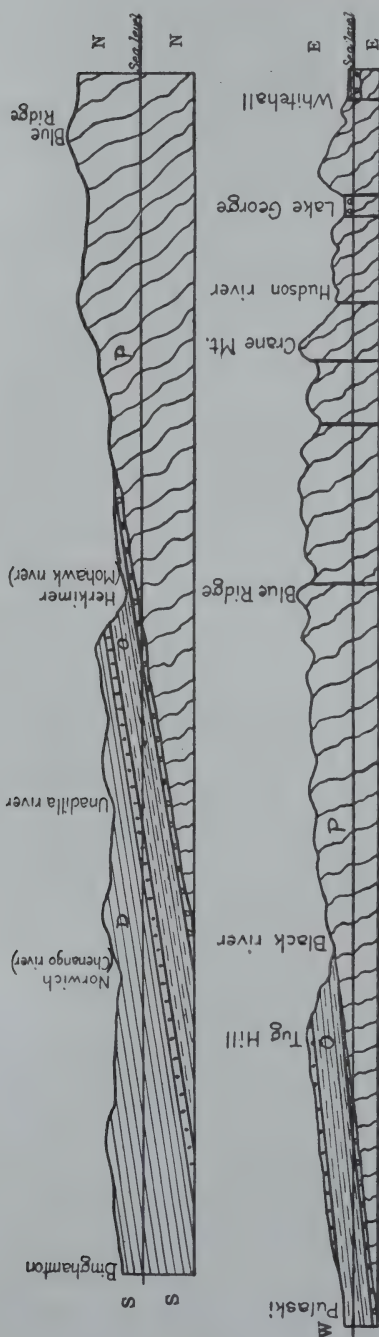


FIG. 7 Diagrammatic sections to illustrate the general relief and relations of the more important rock formations in northern New York. P=Prepaleozoic rock; thin layer next above Cambrian strata; O=Ordovician strata; thin layer next above Ordovician Silurian strata; D=Devonian strata (By W. J. M.)

answer to this question. In many places the Potsdam has been seen in contact with the underlying Prepaleozoic rock whose surface clearly proves that the whole region had reached a peneplain condition. Along the northeastern side of the Adirondacks this peneplain was considerably rougher than along the northwestern, southwestern and southern portions. This is explained by the fact that the northeastern area became submerged first and consequently was not subjected to wear so long as the latter named areas. In the southern Adirondack area occasional low knobs of more resistant rock protruded above the otherwise featureless plain.

The Potsdam sandstone formation is very easily recognizable. It is almost wholly made up of clearly visible, rounded grains of quartz and always well stratified or separated into relatively thin layers. Ripple marks everywhere abound in the sandstone, thus indicating the shallow-water (or near-shore) origin of the deposit. Most of the rock is light gray to cream colored, though in some places pinkish to reddish layers are common. The strata are almost invariably in nearly horizontal position because they have not been notably disturbed since their accumulation in the sea. All the rock in the walls of the famous Ausable chasm (Clinton county) is typical Potsdam sandstone.

Marine conditions continued with the deposition of alternating layers of sandstone and limestone 50 to 200 feet thick upon the Potsdam sandstone. This is called the *Theresa* formation. After still greater subsidence, an important formation known as the *Little Falls* limestone (or dolomitic limestone) was deposited layer upon layer in the comparatively clear waters of this, the latest Cambrian sea. This formation, which is fine grained, dense, light gray in color and well stratified in fairly thick beds, shows its greatest thickness of 500 feet in the gorge at Little Falls in the Mohawk valley. The Little Falls sea swept all around the Adirondacks except what is now the southwestern border from Oneida county to near the Thousand Islands. Occurrence of the formation in the outlying masses at Wells (Hamilton county) and Schroon Lake (Essex county) proves that the Little Falls sea extended well over the eastern and southeastern Adirondack region. The Adirondack island in this latest Cambrian sea was doubtless somewhat smaller than during Potsdam time, though it was still large. Map figure 8 graphically illustrates the approximate relations of land and water during Little Falls time.

Ordovician period. The Cambrian period closed with the emergence of all northern New York above sea level, but very early in

the Ordovician period a submergence of the same region set in, reaching a maximum in the middle of the period. Such emergence and submergence are proved by the fact that the early Ordovician strata rest upon a distinctly eroded surface of the Little Falls (Cambrian) limestone. The duration of the emergence, geologically speaking, was not very long. Even at the time of maxi-

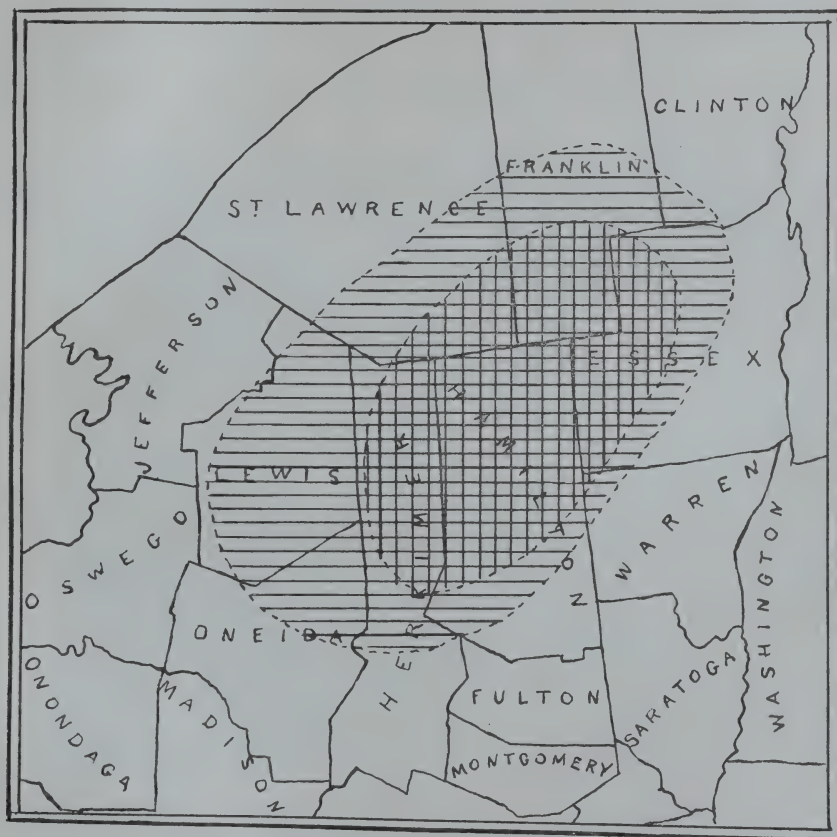


FIG. 8 Sketch map of the Adirondack region showing the general relations of land and water during the Cambrian and Ordovician periods. Horizontal lines: land area during late Cambrian time; cross lines: area of land during the middle of the Ordovician. (W. J. M.)

imum extent of the sea in the mid-Ordovician (figure 8) the evidence is decidedly against complete submergence of the Adirondack region. Occurrence of typical mid-Ordovician (Trenton) limestone and shale in the outlying mass at Wells (Hamilton county) indicates the presence of the Ordovician sea over that

portion of the Adirondacks. But, after making every possible allowance for the former extension of Ordovician strata (since removed by erosion) into the Adirondack region, we are forced to conclude that the central Adirondack area never became submerged under the Ordovician sea. Furthermore, in northern New York there are known to have been various oscillations of level bringing the districts around the persistent central Adirondack dry land now above, and now below, sea level on one side or another. Omitting such details, however, we may say that, except for the Adirondack island, northern New York was mostly below sea level during the Ordovician period.

Surrounding the Adirondacks, the principal Ordovician formations include the *Beekmantown*, *Chazy*, *Black River* and *Trenton* limestones overlain by the *Trenton* (*Canajoharie*), *Utica*, *Frankfort* and *Schenectady* shales and sandstones. It should be made clear, however, that these formations are not all present in unbroken succession all the way around the Adirondacks, because the oscillations of level above mentioned occasioned certain interruptions in the deposition of the strata. These rocks are all typical marine deposits, well stratified, in nearly horizontal position and rich in organic remains. They are the old sea limes, muds and sands which have merely been hardened. The fact that the earlier formations are all limestones indicates relatively clearer ocean waters for that time because the nearest lands were small and low, but in the later Ordovician, muds and sands were washed in from higher, reelevated, adjacent lands.

In the strata of Cambrian age in northern New York, animal or plant remains (fossils) are comparatively rare, while the Ordovician rocks throughout fairly teem with fossils. If any formation deserves special mention, it is the *Trenton* limestone which is exceedingly rich in fossils. The type locality, at *Trenton Falls* in *Oneida* county, is justly famous as a collecting place for Ordovician fossils. As already stated, *Trenton* strata occur in the valley at *Wells* (*Hamilton* county) fully 15 miles within the southeastern Adirondacks and these rocks contain numerous fossils. Among plants, none above very simple seaweeds are known to have existed. Among animals, hundreds of species have been described as occurring within the Ordovician strata of northern New York. These species represent all the more important classes of animals below the vertebrates. Especially prominent are corals, graptolites, echinoderms (so-called star fishes), brachiopods, gastropods and

Plate 18



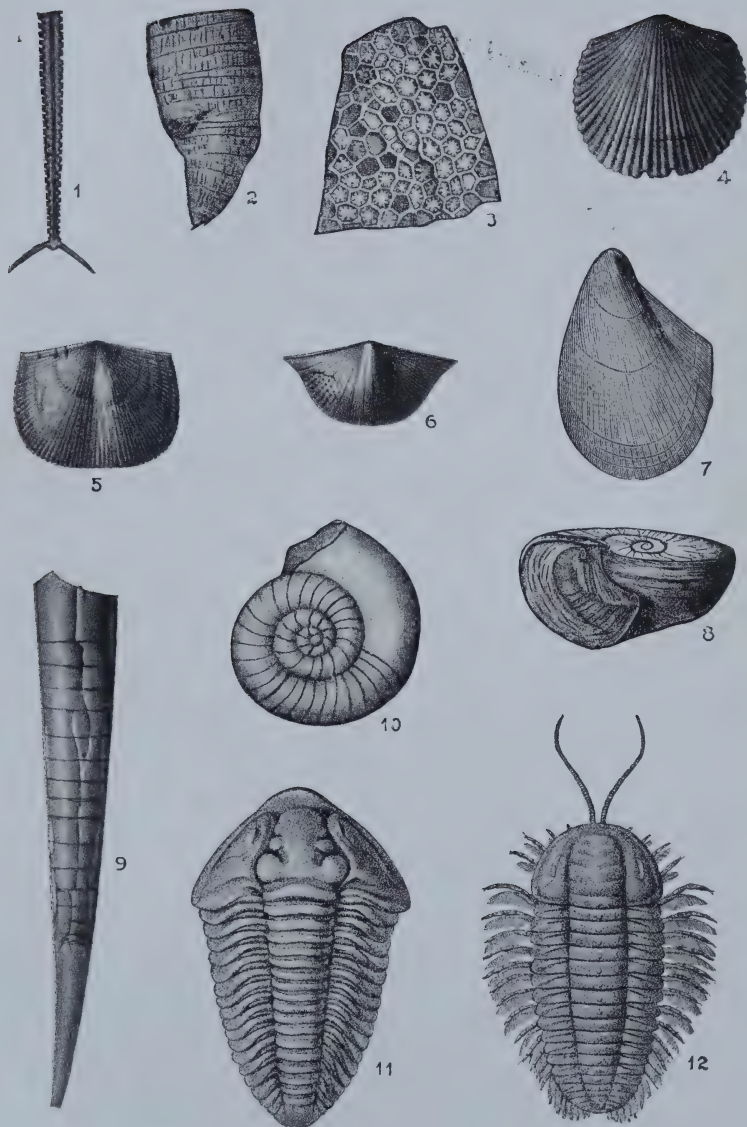
W. J. Miller, photo

An exposure of Lower Trenton (Ordovician) limestone near Wells,
Hamilton county. This rock contains many fossils.

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Plate 19



Some common fossils which occur in the Ordovician strata around the borders of the Adirondacks. Creatures like these lived in the sea which spread over much of the Adirondack area during mid-Ordovician time. 1, Graptolite; 2, Cup coral; 3, Honey-comb coral; 4, 5, 6, Brachiopods; 7, Pelecypod; 8, Gastropod; 9, Cephalopod (Orthoceras); 10, Cephalopod (Trocholites); 11, 12, trilobites (restored forms).

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trilobites. All the organisms mentioned lived in the sea water, and if land forms existed we know nothing of them. It must be borne in mind that not a single species of that time lives today, so complete has been the evolutionary change since Ordovician time. Certain remarkable classes of animals, like the graptolites and trilobites, which often fairly swarmed in the Ordovician sea, have been wholly extinct for millions of years.

At or toward the close of the Ordovician period, a great compressive force was brought to bear upon a thick mass of sediments which reached from north of New England to Virginia, the strata having been highly folded, tilted and elevated far above sea level into a magnificent mountain range known as the Taconic mountains. Accompanying this notable physical revolution, the Adirondack region appears also to have been raised well above the sea though without any folding of the strata. The facts that no post-Ordovician strata occur in or close to the Adirondacks and that there is a distinct break in the sedimentary record between the Ordovician and succeeding Silurian in central New York, strongly support the idea of Adirondack uplift at that time. At about the close of the Ordovician or the opening of the Silurian period, therefore, all northern New York was dry land with the great Taconic range standing out prominently just to the east.

Later Paleozoic history. Early in the Silurian period, sea water encroached upon central New York and kept that area submerged during most of the period. How much, if any, of the Adirondack region was covered by the Silurian sea? The total absence of any rocks later than the Ordovician shales around the Adirondacks and just across the St Lawrence valley strongly suggests that those areas continued as dry land not only during the Silurian but ever since, except for a very brief local submergence after the Ice Age. For the southern Adirondacks the case is somewhat different. Extensive outcrops of Silurian strata just south of the Mohawk river make it certain that these rocks formerly reached farther northward, having since been removed by erosion. But how far northward they extended is a very difficult matter to decide since not a scrap of Silurian strata now occurs north of the Mohawk river. All we can say is that the Silurian sea probably overspread the southern border of the Adirondacks, the sediments there deposited having since been removed by erosion. Abruptly truncated (by erosion) and only slightly tilted Silurian strata on the south side of the Mohawk valley render this view practically certain. In a similar manner the succeeding Devonian sea may have spread over a

portion of the southern Adirondacks, though proofs are wholly lacking. There is no reason whatever to think that any of northern New York was submerged during the last two periods of the Paleozoic era.

The Paleozoic era was brought to a close by one of the most profound physical disturbances in the history of North America. It has been called the Appalachian revolution because at this time the Appalachian mountain range was borne out of the sea by folding and upheaval of the strata. The effect of this revolution upon northern New York is of fundamental importance because the whole region was then raised well above sea level, though without folding of the strata but with moderate tilting toward the south, and true marine conditions never again prevailed over any part of the area.

Mesozoic History

The vast plain of erosion. During all the Mesozoic era most of the eastern portion of the United States was above water and undergoing erosion, so that, by the close of this very long period of wear, the region was reduced to the condition of a more or less monotonous plain near sea level (peneplain). This vast plain extended over the areas of the Appalachian mountains, Piedmont plateau, New York State, the Berkshire hills and the Green mountains. Its most perfect development was in the northern Appalachians. Farther northward, over New York and western New England, its development was less perfect so that certain masses of harder rock stood out more or less prominently above the general level of the plain. In the central and eastern Adirondacks many low mountains of resistant rock rose above the peneplain surface. Hence this second definitely known peneplain of northern New York was not so perfectly developed as that of very early Paleozoic time already described. In a similar manner an occasional low mountain stood out in western New England, and it is probable that the hard sandstones of the Catskills also rose notably above the peneplain.

In the eastern United States the Mesozoic era was closed, or the Cenozoic era opened, by an important physical disturbance which produced an upwarp of the peneplain for from two to three thousand feet following the trend of the Appalachians thence through northern New York. This upward movement was unaccompanied by folding of the rocks, the effect having been to produce a very broad, low arch sloping gently eastward and westward. We are now prepared to make the important statement that the major

topographic (relief) features of northern New York, including the Adirondacks, as we see them today have been largely produced by the erosion or dissection of this upraised peneplain. This being so, are there any remnants of that upraised surface still visible? Where best developed, in the northern Appalachians, the upraised plain has trenches or valleys cut in the belts of weak rock to below the surface of the plain, while the ridge summits at concordant altitudes practically represent portions of the old peneplain surface. In New York State the concordant altitudes are not so well shown both because the peneplain was there not so well developed and because the attitude of the rock masses was largely unfavorable to the production of long, distinct ridges. Remnants of the peneplain are, however, unmistakably present in New York as, for example, on a very large scale over the southwestern plateau district covering thousands of square miles where the highest points mostly reach altitudes of about 2000 feet. The summit of the Tug Hill plateau, just west of the Black River valley also lies at about 2000 feet and is clearly a remnant of the upraised peneplain which formerly connected with the southwestern plateau. As one looks out over the western slope of the Adirondacks from the summit of the Tug Hill plateau, he is impressed by the remarkably even sky line there shown at an altitude of a little over 2000 feet. The central and east-central Adirondacks are exceptional because considerable masses there stood out above the general level of the old peneplain. It is important to note that, as a result of the long time of erosion before and during the Mesozoic era, the Paleozoic strata, which had been deposited well over the borders of the Adirondacks, were considerably removed.

Since the actual work of erosion or dissection of the upraised peneplain in northern New York took place during the next or Cenozoic era, further discussion of this subject is reserved till the consideration of that era.

The great fractures (faults) of the southeastern Adirondacks. Examination of the detailed topographic maps of the eastern and southeastern half of the Adirondacks shows that there are many ridges and valleys, streams and lakes, which trend in a north-north-east by south-southwest direction. What is the explanation of these features? This region has been extensively fractured or faulted. In fact, the major relief features are largely dependent upon this faulted structure. A few words of explanation regarding faults are here in order. Whenever a fracture has developed in the earth's crust and one portion of the earth has slipped by or been pushed

over the other along the fracture, we have what is called a fault. In short, a fault is a fracture in the earth along which there has been slipping. If one portion of the earth simply drops down with respect to the other we have a normal fault, and if one portion has been pushed over the other we have a reversed or thrust fault. Actual movements along a fault surface are sudden, the amount of slipping generally varying from a fraction of an inch to 20 or even 50 feet at a time, though the sum total of all slipping (called "displacement") along large faults, during a long time, often amounts to hundreds or even thousands of feet. Each sudden, notable slipping produces an earthquake. Definitely traced faults vary in length (that is, across country) up to a hundred miles or more. Along such fractures the rocks are often more or less broken or crushed thus affording relatively easy work for stream erosion, so that streams often follow such fault zones of weakness. The eastern and southeastern Adirondacks have been literally chopped to pieces by numerous faults, all of the ordinary normal fault type with fracture surfaces in practically vertical position. No single fault has been proved to extend across the whole region, but rather there is a prominent series of many roughly parallel fractures few of which have been definitely traced as much as 20 miles and none more than 30 or 40 miles. The greatest number are only a few miles long. The total amount of displacement along these fracture lines in the very ancient Adirondack rocks can not be determined, but frequently it is at least 500 to 2000 feet. This series of faults cuts through the early Paleozoic strata along the shores of Lake Champlain and in the Mohawk valley, and in these regions, due to marked differences in the character of the strata, it has been possible to determine the amounts of displacement with considerable accuracy.

In addition to this great series of north-northeast by south-southwest faults, there are many others, mostly minor ones, which trend in various directions, though chiefly approximately at right angles to the major series. Accordingly, the eastern and southeastern Adirondack region is really a mosaic of earth blocks and ridges. Since their origin most of these blocks and ridges have of course been appreciably modified by erosion. Sometimes there is no positive evidence of any notable displacement, though the rocks in the fault zone are badly broken. The geologic map of the Lake Pleasant quadrangle affords an excellent illustration of numerous faults and their evident influence upon the topography in the very

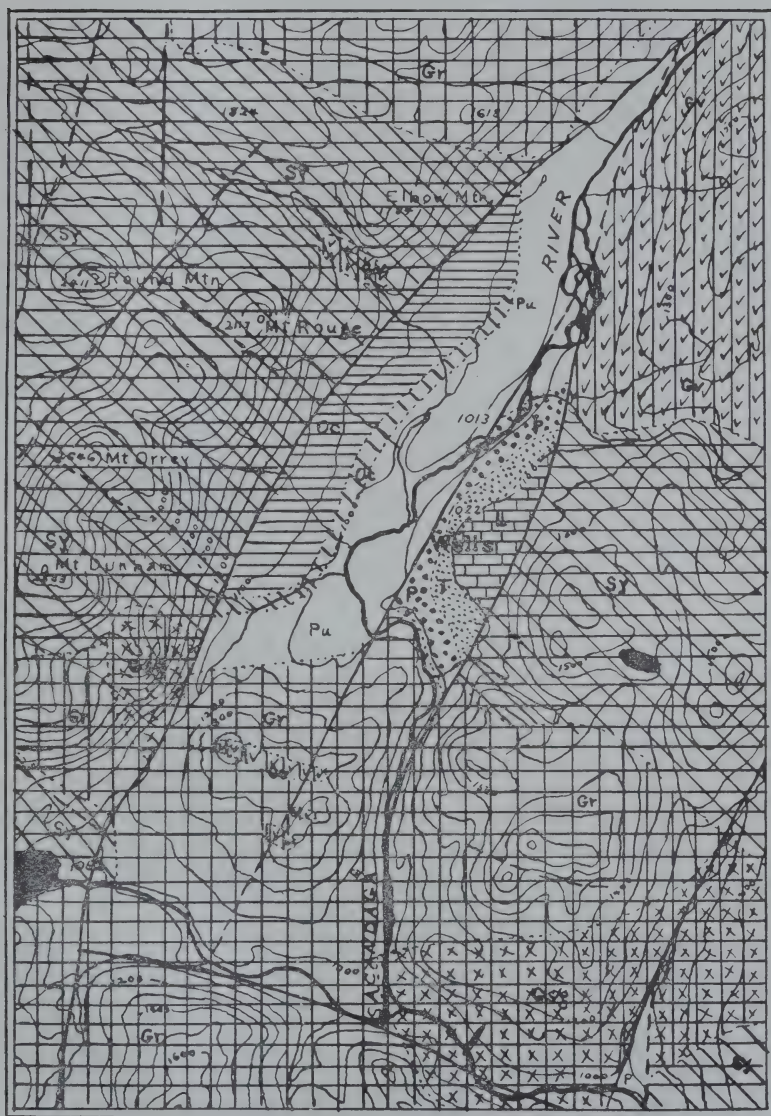


FIG. 9 Geologic and topographic map of the vicinity of Wells showing the relations of various rock formations and several conspicuous faults. Contour interval: 100 feet. Positions of faults represented by heavy black lines. Gv=Grenville strata; Sy=syenite; Gr=granite; Gsg=Grenville-syenite-granite mixed rocks; black areas=gabbro or diabase; P=Potsdam sandstone; T=Theresa formation; L=Little Falls limestone; O=Lower Trenton limestone; Oc=Canajoharie (Trenton) shale; Pu=Paleozoic strata. Geology by W. J. Miller.

midst of that part of the Adirondacks here considered. The small outlying mass of Paleozoic strata at Wells, so far separated from the main body of similar strata, lies within a valley of the Lake Pleasant quadrangle. This valley and its immediate surroundings exhibit perhaps a greater variety of important geologic phenomena than any other small area within the whole Adirondack region (see map figure 9). A fault whose total length is over 30 miles passes along the western side of the valley where the mountain wall of pre-Paleozoic rock (see figure 9) rises 1000 to 1500 feet, while the

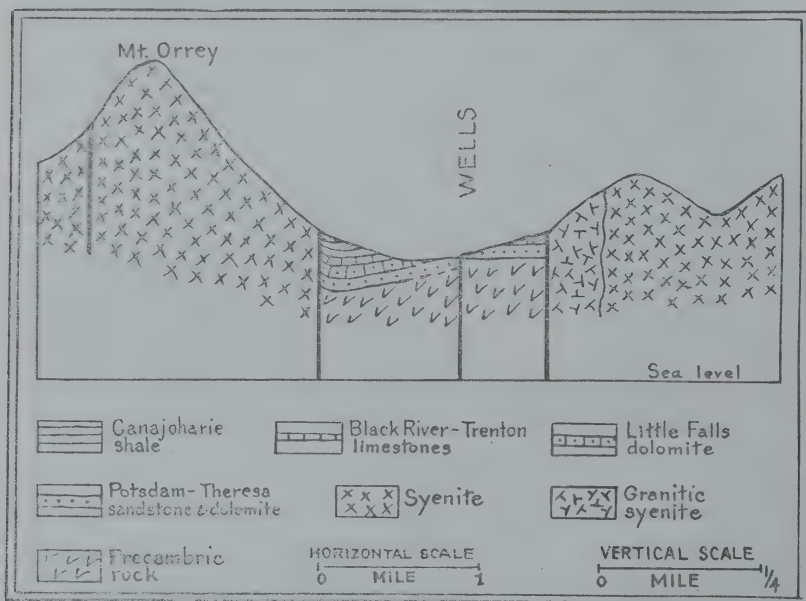


FIG. 10 Detailed structure section across the valley at Wells, Hamilton county. This represents a vertical slice through the earth's crust at this locality. The dolomite, sandstone, limestone and shale are Paleozoic strata. Heavy vertical lines show positions of faults. (By W. J. M.)

eastern or valley side of the fault represents a portion of the earth's crust which has moved downward at least 2000 feet (figure 10). The Paleozoic strata in the valley were formerly at a level corresponding nearly to the present mountain tops just to the west of the fault. Having dropped down so near sea level, these strata, now about 500 feet thick, have been protected against complete removal by erosion to the present time. Another, though smaller, fault bounds the valley on the east, so that the valley really represents a block of earth which has dropped down between two faults.

Of course the topographic outlines have been notably modified by weathering and erosion. This valley at Wells has been referred to somewhat in detail because it so clearly illustrates the principles of Adirondack faulting.

When were the faults developed? That at least some fracturing occurred in Prepaleozoic time has been established, but, so far as known, such faults have relatively little influence upon the existing relief features. Also it is probable that fault movements took place during the Paleozoic era, but if so the old fault cliffs or ridges must have been practically obliterated by erosion during the Mesozoic era concluding with the development of the great plain of erosion already described. If so, how do we account for the present Adirondack ridges and valleys which owe their existence chiefly to faulting? Accompanying the uplift of the peneplain there was either much faulting for the first time, or renewed faulting along old lines of fracture, or, as a result of unequal erosion due to differences in rock character on opposite sides of old faults, new cliffs or scraps began to be produced. That much of the faulting actually dates from the uplift of the peneplain, or possibly even later, is proved by the existence of certain steep cliffs in perfectly homogeneous rock masses and by the distinct tilt of many of the fault blocks, both of which features have been scarcely modified by erosion since their development.

Cenozoic History not Including the Ice Age

Development of existing major relief features. The uplift of the great peneplain was an event of prime importance for northern New York because it literally furnishes us with the beginning of the history of most of the principal existing relief features of the region. Hence we reassert with emphasis that the chief topographic features of the State have come into existence since the uplift of the peneplain because they have been produced by the dissection of that upraised surface. This dissection was largely the work of erosion, though, as already explained, faulting produced notable topographic effects in the eastern and southeastern Adirondacks. Also it should be borne in mind that the central to east-central Adirondack area stood out with many masses above the general peneplain level. Since the uplift, however, this area has been deeply trenched and made very rugged as we see it today. All the great valleys around the Adirondacks—the St Lawrence, Champlain, Mohawk and Black river—have been carved out of the upraised peneplain,

though faulting has no doubt been a notable factor in the production of the Champlain valley. The numerous lakes, gorges and waterfalls of the Adirondacks have all come into existence during Cenozoic time, most of them since relatively late Cenozoic time.

During the Cenozoic era, still more of the Paleozoic strata which rested upon the Prepaleozoic rocks and extended over the present borders of the Adirondacks were stripped off by erosion until the present condition has been reached. This removal of Paleozoic strata around the Adirondacks is still going on, thus gradually enlarging the area of the very ancient Prepaleozoic rocks. The little masses of Paleozoic strata well within the Adirondack borders such as those at Wells, Schroon Lake, North River, etc., are merely erosion remnants of the mantle of Paleozoic sediments which formerly spread over all the southeastern Adirondack area.

Of much greater influence than the faulting in the production of the present-day Adirondack relief features has been the difference in character of the rock masses. Thus the relatively weaker Grenville strata (especially limestone) have almost invariably been worn down to form the valleys, while the harder and more resistant anorthosite, granite and syenite have stood out better against the weathering and erosion to form the mountains. It will be recalled that the Grenville strata and the igneous rocks are very irregular or "patchy" in their distribution. For this reason the valleys and mountains have been carved out in a most irregular manner throughout the Adirondack region except where the faulting has had a notable influence. In many instances in the faulted region, streams have cut relatively straight channels for greater or lesser distances along the broken-rock fault zones. But by no means all the relief has developed either as a result of differences of rock character or faulting, because even in large masses of very homogeneous hard rocks many streams have developed channels of varying size and shape in a most irregular manner.

The evolution of drainage. Almost nothing is definitely known about the positions of drainage lines in northern New York before the Cenozoic era began. Since the uplift of the peneplain in the late Mesozoic or early Cenozoic, however, the drainage history of the Adirondacks is fairly known. As already pointed out, the present Adirondack streams show a very marked tendency to radiate from the central portion of the district. The Adirondack region is now a broad, relatively low, domelike mass fully a hundred miles across with altitudes commonly ranging from 1000 to several thousand feet, the central to east-central portion being the highest.

This domelike character of the Adirondacks has apparently been a very persistent feature for many millions of years, or at least since the beginning of the Paleozoic era, and this in spite of profound erosion. It will be recalled that the interior of the region was a large, low island in the midst of the early Paleozoic seas. Uplift of northern New York toward the close of the Paleozoic era, and consequent removal by erosion or much of the bordering Paleozoic strata, no doubt renewed the prominence of the Adirondack dome. Next, during the long time of the Mesozoic era, the region was worn down to a fairly good peneplain except from the central to the east-central portion. Then came the late Mesozoic or early Cenozoic uplift of this peneplain, apparently with greatest elevation corresponding roughly to the present north-northeast by south-southwest main axis (see above) which extends across the Adirondack region. Naturally the streams which began to operate upon this newly upraised domelike surface flowed outward from the highest or central to eastcentral Adirondack district. During the long Cenozoic time, the weak Paleozoic strata were still further removed from the sides of the ancient dome of the Adirondack (Prepaleozoic) rock, thus accentuating it as a topographic feature and permitting the streams to adjust themselves to a more and more perfect radiation in all directions from the higher central portion. Certain important drainage changes have been brought about by the recent Ice Age and these will be described below, but they do not seriously affect the conclusions just reached regarding the drainage.

Immediately after the uplift of the peneplain, some of the easterly headwaters of the Susquehanna river came out of the southwestern Adirondack district. Among the evidences are the following: The Mohawk valley had not then come into existence the slope of the upraised peneplain surface was there southward; and the numerous sources of the Susquehanna which now rise at the very brink of the Mohawk valley on the south side strongly suggest that these streams once started some miles farther northward. As a result of the development of the Mohawk valley, these upper waters of the Susquehanna in the southern Adirondacks have been captured and diverted into the Mohawk river.

The Great Ice Age

Ice extent and direction of movement. The Quaternary is the last period of earth history and it still continues for it has led up to the present-day conditions. This period was ushered in by the spreading of vast ice sheets over much of northern North America

and Europe. This event takes rank as one of the most interesting and remarkable occurrences of geological time.

Some of the proofs for the former presence of the great ice sheet are the following: (1) polished and scratched rock surfaces which are precisely like those produced by existing glaciers, and which could not possibly have resulted from any other agency; (2) glacial boulders called "erratics" which are often somewhat rounded and scratched, and which have often been transported many miles from their parent ledges; and (3) glacial deposits, including true moraines (see below) and the widespread heterogeneous glacial *débris*, both stratified and unstratified, which is clearly ice transported material usually resting by sharp contact upon the bedrock.

An area of nearly 4,000,000 square miles of North America was covered by ice at the time of maximum glaciation and also there were three main centers of ice accumulation and dispersal, namely, the Labradorean, Kewatin and Cordilleran. It was the Labradorean ice sheet which spread southward to cover all of the Adirondacks. The directions of flow of the ice have been determined by noting the directions of the glacial scratches (so-called "striae").

When the Labradorean ice sheet spread out southward as far as northern New York, the Adirondack mountains stood out as a considerable obstacle in the path of the moving ice. Hence the tendency was for the ice to divide into two currents or portions, one of which passed southwestward up the low, broad St Lawrence valley, and the other due southward through the deep, narrow Champlain valley. As the ice kept crowding from the rear, part of the St Lawrence ice lobe pushed into the Ontario basin, while another portion pushed its way up the deep Black River valley and finally into the Mohawk valley in central New York. At the same time the Champlain ice lobe found its way into the Hudson valley and sent a branch lobe westward up the Mohawk valley. The two Mohawk lobes, the one from the west and the other from the east, met in the Mohawk valley not far from Little Falls. As the ice sheet continued to push southward, all the lowlands of northern New York were filled, and finally the whole Adirondack region was buried under the ice. The highest, or central to east-central, Adirondacks were the last to become submerged under the ice. The general direction of movement at this time of greatest ice extent was southward to southwestward with perhaps some undercurrents determined by the larger topographic features.

The accompanying maps (figure 11) depict three important stages in the retreat of the ice sheet from northern New York. It



FIG. 11 Maps showing three stages in the recession of the great ice sheet from New York State. Upper figure: the Adirondack mountains completely buried under the ice; middle figure: the Adirondacks largely freed from the ice; lower figure: the Adirondacks wholly freed from the ice. Note the position of the large lake in the Black River valley; standing water in the Hudson valley and in the Lake George depression; and the outlet of the Great Lakes through the Mohawk valley. (After H. L. Fairchild, from Tarr and Martin's "College Physiography," by permission of The Macmillan Company).

will be seen that the central Adirondacks, the last to be buried, were the first to be freed from the ice, the much thicker ice in the surrounding valleys requiring a longer time for melting. Taken in reverse order, these maps in a general way show three stages in the advance of the ice over New York State.

Ice erosion. Glacial ice, like flowing water, has very little erosive effect upon rocks unless it is properly supplied with tools. When flowing ice is shod with hard rock fragments, the power to erode is often pronounced because the work of abrasion is mostly accomplished by the rock fragments rather than by the ice itself. A little search will reveal polished and scratched rock surfaces in the Adirondacks, and the freshness and hardness of the surface rock proves that the ice eroded off all the preglacial soil and rotten rock and often more or less of the fresh rock. During the very long preglacial time, rock decomposition must have progressed so far that rotten rock, including soils, had accumulated to considerable depths as is the case in the southern states today. Such soils are called "residual" because they are derived by the decomposition of the very rocks upon which they rest. But now one rarely ever sees rotten rock or residual soil in its original position in the Adirondacks because such materials were nearly all scoured off by the passage of the great ice plow, mixed up with other soils and ground up rock materials and deposited elsewhere. Such are called transported soils.

Ice shod with hard rock fragments, and flowing through deep, comparatively narrow valleys of relatively soft rock, is particularly powerful as an erosive agent, because the tools are supplied, the work to be done is easy, and the increased depth of ice where crowded into such a valley causes greater pressure on the bottom and sides of the valley. Many of the valleys of northern New York were thus favorably situated for ice erosion, as, for example, the Champlain, St Lawrence and Black River valleys as well as many of the north-south valleys of the Adirondacks.

Most of the Adirondack mountain peaks, especially the more isolated ones, were thoroughly scraped off and rounded down to the very fresh rock, while the favorably situated valleys were vigorously glaciated by the removal of all the rotten rock and at least some of the fresh rock, especially when this latter was comparatively soft, Grenville limestone. Such phenomena are particularly well exhibited in Warren county where the landscape is characterized by numerous glaciated rock domes which rise conspicuously above the valleys of weak Grenville. In some cases where the ice moved

directly across deep valleys, like that between Lake George village and Warrensburg, the rotten rock to a considerable depth may still be seen in its original place.

In conclusion we may say that, while many comparatively small local features were produced by ice erosion, the major topography of the Adirondacks was essentially unchanged by ice erosion.

Local mountain glaciers. Certain mountainside valleys have been notably modified by small so-called Alpine or valley glaciers which existed either just prior to or just after the great Ice Age in northern New York. On first thought it seems reasonable to assume that such valley glaciers were lingering remnants of the vast sheet of ice. But the absence of anything like distinct moraines produced by such glaciers strongly argues for their existence just before the Ice Age, such morainic deposits having been obliterated by the passage of the great ice sheet. Excellent examples of valleys once occupied and modified by local glaciers are the deep, nearly U-shaped trenches down the eastern and northern sides of Whiteface mountain and down the northern end of the Sentinel range, all within the Lake Placid quadrangle.¹

Glacial deposits. The vast amount of *débris* transported by the great ice sheet was carried either on its surface, or frozen within it or pushed along under it. It was exceedingly heterogeneous material ranging from the finest clay, through sand and gravel, to boulders of many tons weight. The deposition of these materials as we now see them took place during both the advance and the retreat of the ice, but chiefly during the retreat. Most of the deposits made during the ice advance were obliterated by ice erosion, but those formed during the ice retreat have been left intact except for the small amount of postglacial erosion.

Whenever, during the great general retreat, the ice front remained stationary for some time because the forward motion of the ice was just counterbalanced by the melting, all the ice reaching the margin dropped its load of *débris* to build up a *terminal moraine*. This is usually a distinct ridge of low hills consisting of very heterogeneous, mostly unstratified, *débris*. Such moraines are not commonly well developed in the Adirondacks.

A very extensive glacial deposit, called the *ground moraine*, is simply the heterogeneous, typically unstratified *débris* from the bottom of the ice which was deposited mostly during the melting and retreat of the ice. When it is mostly very fine material with

¹ Prof. D. W. Johnson has recently noted a moraine in one of the valleys of Mt. Whiteface and he argues that it was produced by a local glacier which existed after the retreat of the great ice sheet.

pebbles or boulders scattered through its mass, it is known as *boulder clay* or *till*. The pebbles or boulders of the till are commonly faceted and striated as a result of having been rubbed against underlying rock formations. Such ground moraine deposits are exceedingly widespread throughout the Adirondacks.

An interesting type of glacial deposit is the *drumlin* which is, in reality, only a low, rounded hill of ground moraine material or till. These are practically unknown in the Adirondacks, though some excellent examples occur on the southern border in the vicinity of Gloversville (Fulton county).

Glacial boulders, or so-called *erratics*, have already been referred to. They are simply blocks of rocks or boulders from the top of the ice or within it which have been left strewn over the country as a result of the melting of the ice. They vary in size from small pebbles to those of many tons weight and are naturally most commonly derived from the harder rock formations. Erratics are very numerous throughout the Adirondacks. They are most numerous on the lower lands, though by no means rare on the mountains. Sometimes they have been left stranded in remarkably balanced positions. The writer has frequently noted boulders and pebbles of Potsdam (Cambrian) sandstone, derived from the St Lawrence valley, at altitudes of from 3000 to 4000 feet in the central and east-central Adirondacks. Boulders of anorthosite from Essex county are not rare at the southern border of the Adirondacks.

Another type of glacial deposit in the low hill or hillock form is the *kame* which, in contrast with the drumlin, always consists of stratified (water-laid) material. Kames are seldom as much as 200 feet high, and typically they have nearly circular bases though frequently they are very irregular in shape. At times they exist as isolated hills or in small groups, but often they are associated with the unstratified morainic deposits. They were formed by débris-laden streams emerging from the margin of the ice, the water sometimes having risen like great fountains because of pressure. Such deposits are now in process of formation in Alaska. Kames are very common in the Adirondacks.

The *esker* also consists of stratified glacial material, but it is in the form of a low, winding ridge formed near the ice margin either by subglacial streams or in cracks in the ice. Eskers may occasionally be seen in the Adirondacks, an exceptionally fine one having a highway at its summit in Thirty-four marsh just east of Blue Mountain lake. Another fine one, about a mile long, lies just west of Schroon Lake village.



W. J. Miller, photo

A great glacial boulder near Loch Muller, Essex county. The rock is anorthosite, and it has been carried some miles at least from its parent ledge. Its dimensions are approximately 33 feet long, 27 feet wide, and 25 feet high. Due to weathering and freezing of water along a natural fracture (so-called "joint") the boulder has been split open since it was left by the ice.

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Plate 21.



H. P. Cushing, Photo.

Bluff produced in kame sand ridge at Moody, Tupper Lake shore. Cross-bedding shows midway at the top.

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Like glacial erosion, the deposition of glacial materials has not changed the major topographic features of northern New York. The general tendency of ice deposits has been partially to fill depressions and thus to diminish the ruggedness of the relief.

Origin of the lakes. The numerous Adirondack lakes constitute one of the most striking differences between the geography of the present and that of preglacial time. Before the Ice Age practically none of the lakes was in existence, the bodies of water having been produced either directly or indirectly by glacial action. Among the methods of lake basin formation were building dams of glacial débris across old river channels or valleys; ice erosion; and the production of depressions by irregular accumulation of glacial débris or by the melting of large blocks of ice which were more or less submerged under glacial débris.

Most of the lakes were formed by dams of glacial material thrown across valleys. It is quite the rule to find the outlets of these lakes flowing through loose materials of this sort. By ice erosion, many of the favorably situated valleys were somewhat modified, but there are few, if any, lake basins produced wholly by that process. There are many examples of ponds and small lakes which occupy depressions below the general level of certain sand flats, the sands having been deposited in glacial lakes during the retreat of the ice, and the depressions resulted from the subsequent melting of blocks of ice which were surrounded by the sand deposits. Numerous examples of such ponds occur within the St Regis quadrangle and on the great sand plain along the eastern side of the Black River valley.

Sometimes small lakes or ponds are situated well up on high mountains. Examples are on Crane mountain (North Creek quadrangle) at 2620 feet; Morgan pond on Wilmington mountain (Lake Placid quadrangle) at 3020 feet; on the mountain $1\frac{1}{2}$ miles due north of Indian pass (Santanoni quadrangle) at 3550 feet; and the Wall Face ponds 1 mile northwest of the same Indian pass at 3040 feet. Perhaps highest of all is Lake Tear, sometimes called Lake Tear of the Clouds, at 4300 feet close to the divide between Mt Marcy and Mt Skylight. This is one of the sources of the Hudson river.

Many of the Adirondack lakes were formerly larger, as proved by delta deposits above the present lake levels. Two examples which have recently come under the writer's observation are Schroon lake and Piseco lake. The water of Schroon lake was once fully 70 feet higher when it extended some 8 or 10 miles farther up the Schroon valley with an arm reaching over the area of the present Paradox

lake, and also some 6 or 8 miles southward covering all the lowland around Chestertown and an arm extending over the area of the present Brant lake. Piseco lake was at one time 20 feet higher, when it reached several miles farther northward. Both of these lakes lie in valleys which are largely due to faulting as explained above. The waters of both are now held up by dams of loose glacial *débris* across the south ends.

Lake George is justly famous because, from the standpoint of length and depth in proportion to width, no other lake in the State occupies such a remarkable valley. This depression has been produced by a combination of faulting and erosion. There was a pre-Glacial divide at the present location of the "Narrows." This divide may have been considerably lowered by ice erosion when the deep, narrow body of ice plowed its way through the valley. The waters are now held up by glacial deposits at each end.

Lake Placid occupies the bottom of an irregular preglacial valley. The lake has been formed by heavy glacial deposits across the valley on the south. The very low neck of land separating it from Mirror lake is also glacial material.

The Saranac lakes, Big Tupper lake and Cranberry lake are large bodies of water of very irregular shape in shallow basins resulting from the accumulation of glacial *débris* across broad, preglacial valleys.

Raquette lake, with its exceedingly irregular shore line, lies in the bottom of a broad, shallow preglacial valley or rather portions of several adjacent valleys. Heavy glacial deposits on the south act as a dam.

Both Long lake and Indian lake, two fine examples of the linear type of lake, lie in the bottoms of very straight valleys which have been carved out by erosion along fault zones of weak rock. Much of the present extent of Indian lake is due to an artificial dam across the northern end.

The Fulton chain of lakes are the result of irregular damming of prominent preglacial stream valleys by glacial *débris*.

Blue Mountain lake, Lake Pleasant and Sacandaga lake all lie in the bottoms of valleys which appear to have been carved out of relatively weak Grenville strata, the waters being held up by glacial *débris* dams. A low, narrow neck of glacial material serves to separate Lake Pleasant and Sacandaga lake.

Extinct lakes. Hundreds of extinct glacial lakes are known to be scattered throughout the Adirondacks. Some of these existed only during the time of the ice retreat where the ice acted as dams across valleys, while others existed for a greater or lesser time after

the Ice Age. The locations of many such extinct lakes are easily recognized by the more or less well-preserved, typical, flat-topped delta deposits of stratified sands, gravels and clays. Such flat-topped deposits, always free from boulders and at concordant altitudes in the valleys, mark the former lake levels. The sites of many other extinct lakes are now marked by flat meadow lands or swampy areas, the lakes having been filled by sediments or plant accumulations or by both. Swamps and meadowlands of this sort are exceedingly common throughout the Adirondacks, and constitute one of the characteristic features of the region.

Perhaps the finest example of a large, wholly extinct glacial lake in the State has been called Black lake which occupied a good portion of the bottom of the Black River valley in the western side of the Adirondacks. The water was held up by a wall of ice during the retreat of the great ice sheet (see figure 11). The former presence of this lake, which covered many square miles, is conclusively proved by the extensive development of delta sand plains on the eastern side of the valley, the delta materials (chiefly sand and gravel) having been brought into the lake by streams loaded with debris from the newly ice-freed Adirondacks. These delta deposits became more or less merged and they now form an extensive sand plain over 30 miles long, several miles wide and fully 200 feet thick on the steep western side (figure 12).

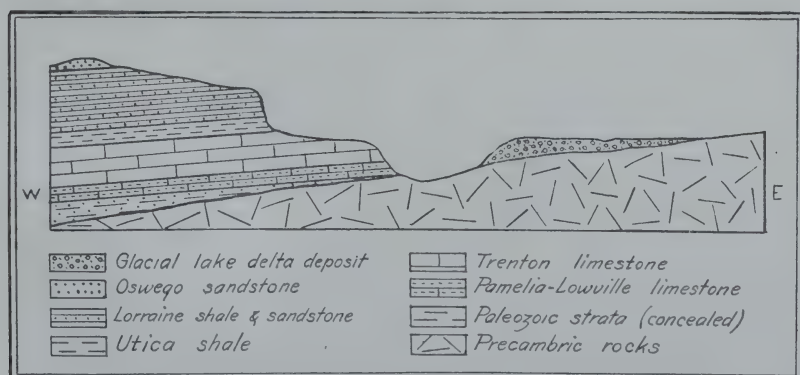


FIG. 12 East-west section across the Black River valley, $2\frac{1}{2}$ miles north of Lyons Falls, showing the terraced character of the Paleozoic strata and their relations to the Adirondack rocks. On the east side, the position of the glacial lake delta deposit is shown. Length of section $12\frac{1}{2}$ miles. Vertical scale greatly exaggerated. (By W. J. M.)

Another fine example of a large extinct lake has been called Glacial Lake Sacandaga. It covered many square miles of the bottom of the broad valley in which Johnstown, Gloversville and

Northville are located. During the general ice retreat, but when the Mohawk valley lobe of ice was still present, morainic deposits accumulated along the ice margin across the mouth of the valley thus ponding the waters over the valley bottom and causing the Sacandaga river to find an outlet over the low divide at Conklingville. Perfect delta sand plains may now be seen at approximately 780 feet above sea level. This lake persisted for a good while after the disappearance of the ice because of the effective morainic dam, and even today in the spring of the year a wide swamp becomes flooded. The lake was drained by cutting down the outlet at Conklingville. Construction of the proposed Sacandaga reservoir, by means of a dam at Conklingville, would almost exactly restore this former glacial lake.

Great terraces and sand flats show the former existence of a large body of water in the valley around Corinth (Saratoga county), and another in the vicinity of Warrensburg (Warren county).

The former extensive lake, called Glacial Lake Pottersville, of which Schroom, Brant and Paradox lakes are remnants, has already been described. Numerous excellent delta sand flats mark the old lake level. Construction of the Schroom lake reservoir, as proposed by the State, would almost exactly restore this great lake.

A well-defined glacial lake filled the bottom of the valley at Wells (Hamilton county).

In the northeastern Adirondacks there were, according to Mr H. L. Alling, several extensive high-water lakes, the principal ones having been in the Saranac lakes valley with water levels ranging from 1600 to 1450 feet (present altitudes); in the broad valley south and southeast of Lake Placid with water levels from 1875 to 1800 feet; and in the broad valley around Wilmington with waters at from 1150 to 1100 feet.

The above-described extinct lakes are only some of the more important ones which have been studied in the Adirondack region.

Drainage changes due to glaciation. Drainage changes due to the Ice Age are common in the Adirondacks, though many of these have not yet been worked out in detail. Some of the more prominent changes which have been studied will be briefly described. As a result of long preglacial erosion, it is certain that deep, narrow gorges and waterfalls must have been very rare if present at all. Like lakes, such features are ephemeral because, under our conditions of climate, gorges soon (geologically) widen at the top, and waterfalls disappear by retreat or by wearing away the hard rock over which they fall.

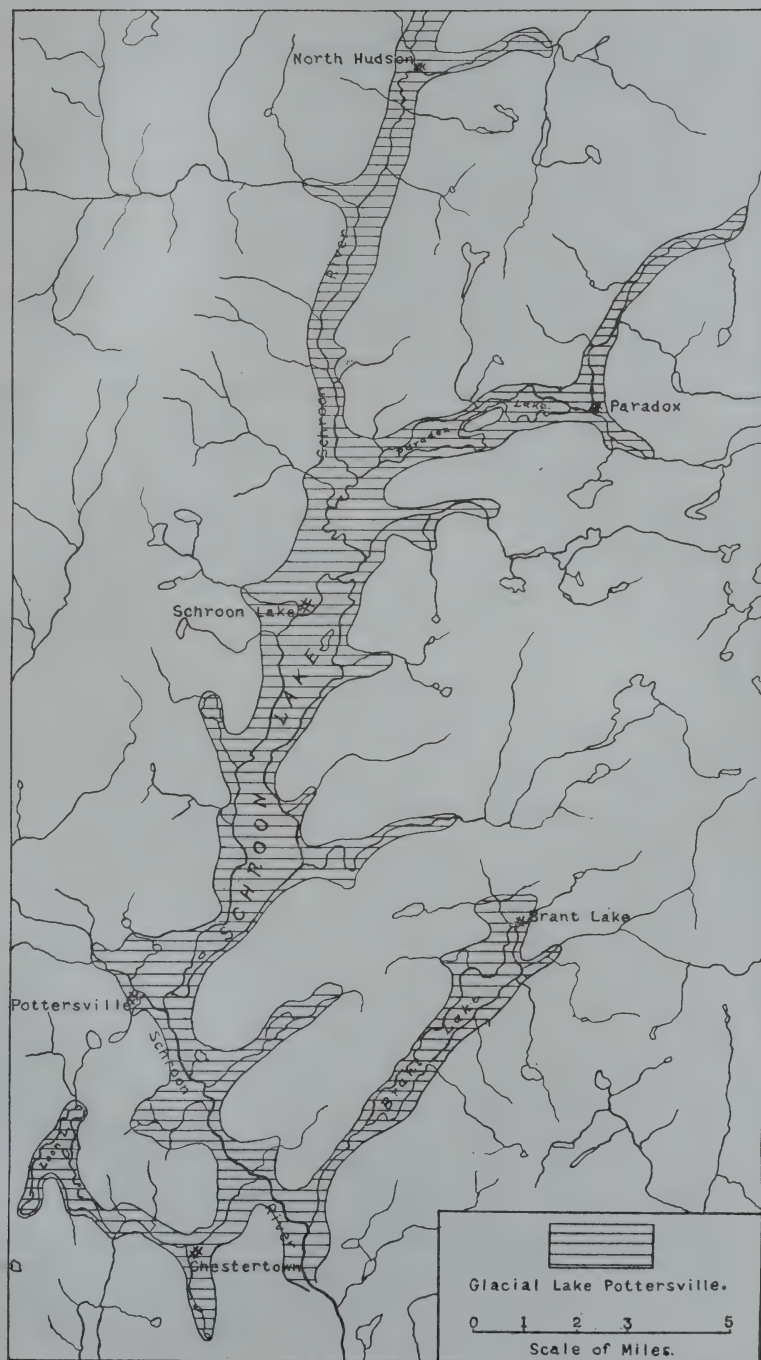


FIG. 13 Sketch map to show the extent of Glacial Lake Pottersville in Warren and Essex counties during the waning of the ice sheet from the Adirondack region. (By W. J. M.)

In the southeastern Adirondacks, it is no exaggeration to say that the larger drainage features have been revolutionized as a result of glaciation. The accompanying sketch map (figure 14) gives a fair idea of the changes, but the interested reader should also refer to the topographic maps of the region. At the southeastern border of the Adirondacks, two prominent valleys extend southward for some miles, one from Northville toward Gloversville, and the other from Corinth toward Saratoga Springs. Each valley is underlain with Paleozoic strata and each is bounded on east and west by highlands of hard prepaleozoic rocks. It is certain that these valleys contained normal preglacial rivers which flowed southward out of the mountains. Now, however, the Sacandaga river enters the north end of the first-named valley only to make a very sharp turn back on its course to flow across the mountains and into the Hudson river at Luzerne. A preglacial divide was located at Conklingville as shown by the gorge there; the perfectly graded condition of the valley bottom westward from that place; and the increasing width of the valley westward. This remarkable deflection of the river was caused by the building of a broad morainic blockade across the valley through Gloversville and Broadalbin as already explained. For a long time a lake occupied the valley bottom just north of the blockade dam.

The Hudson river now flows through a gorge fully a thousand feet deep just north of Stony Creek station, and thence to the north end of the prominent Paleozoic rock valley at Corinth where it turns abruptly to the northeast to flow across the Luzerne mountain ridge. The preglacial Hudson certainly did not flow through the Stony Creek gorge, but rather, where the gorge now is, there was an important divide. The Hudson and Schroon rivers both make anomalous turns to the southwest and join to flow through a highland region of hard rocks instead of continuing southeastward through one of the low passages in the vicinity of Warrensburg and into the Lake George basin as shown on the map. The now extinct Luzerne river started on the Stony Creek divide, flowed southward past Corinth and thence through the broad, low Paleozoic rock valley to the west of Saratoga Springs. The cause of the passage of the Hudson over the Stony Creek divide was due chiefly to the fact that during the ice retreat the glacial lobe in the Lake George basin forced the river to take a more westerly course where the channel was cut down deep enough so that the river kept that course even after the melting of the ice. The deflection of the river over the Luzerne mountain divide was caused by heavy glacial accumulation in the valley at Corinth.

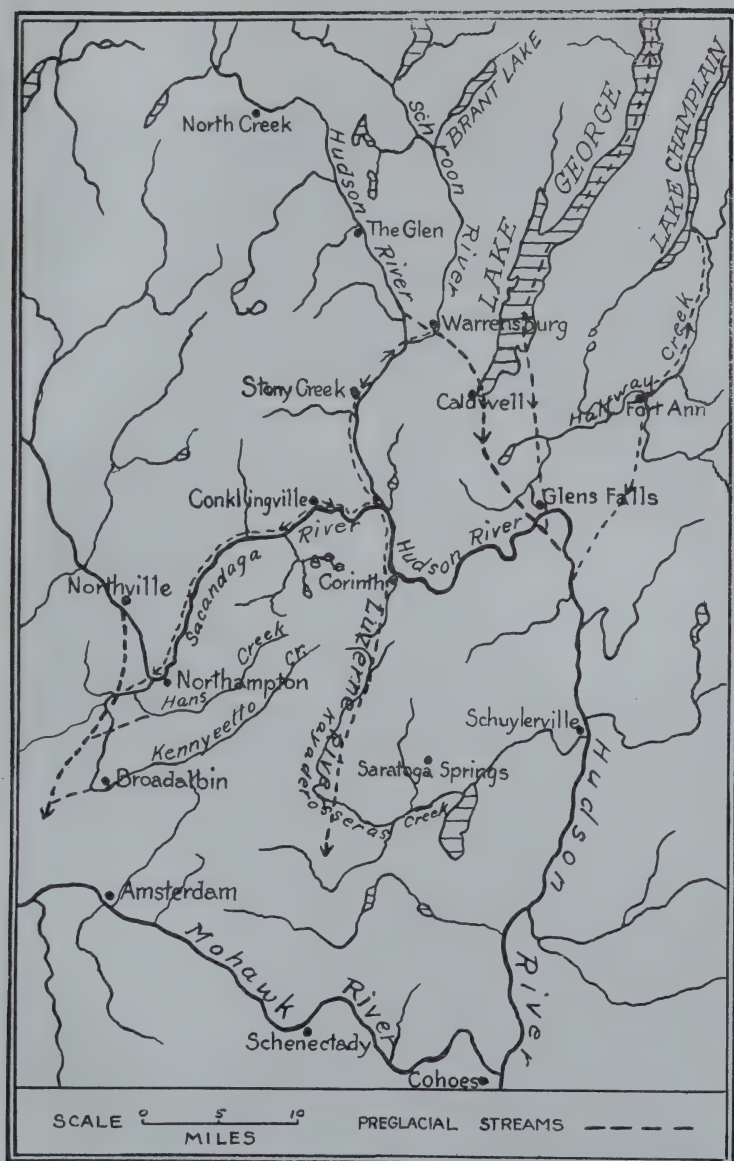


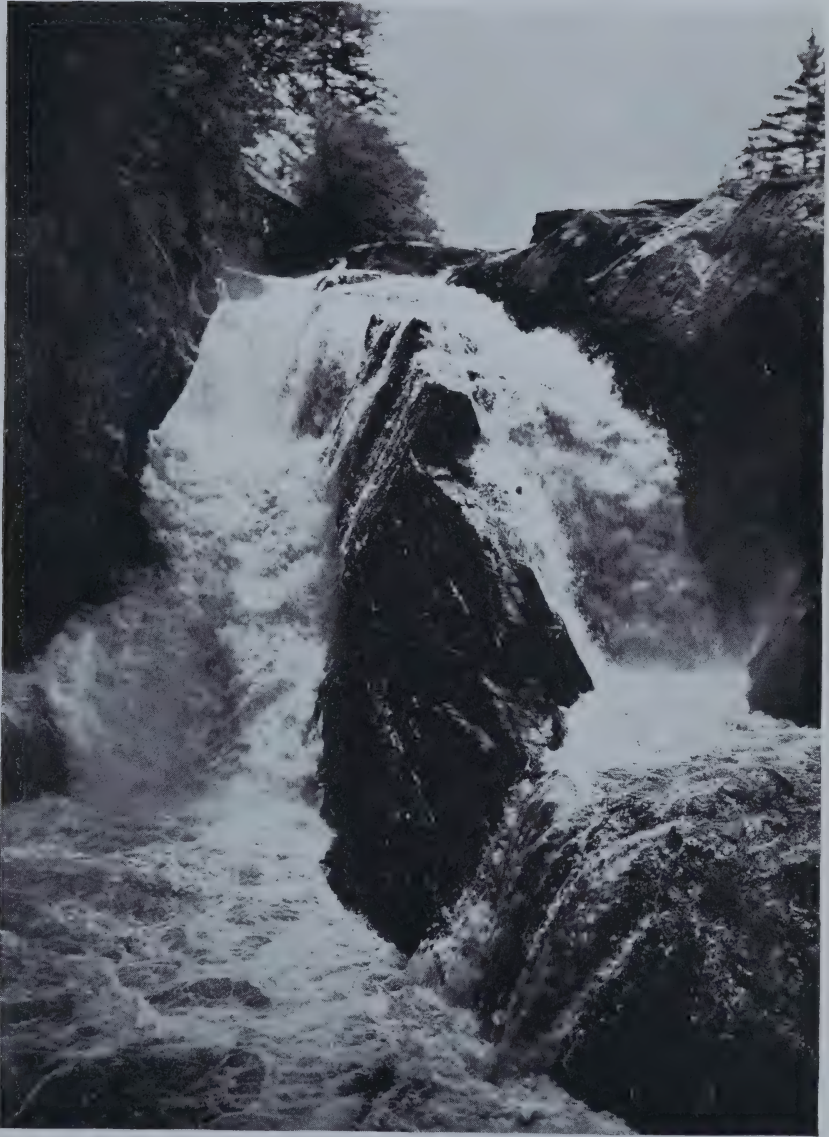
FIG. 14 Sketch of the southeastern Adirondack region, showing the relation of the preglacial drainage to that of the present. Preglacial courses shown only where essentially different from present streams. (By W. J. M.)

Other conspicuous drainage changes have taken place in the heart of the Adirondacks. Before the Ice Age the basins now occupied by Blue Mountain and Eagle lakes quite certainly drained eastward into the Hudson river by way of Rock river instead of westward as at present through Raquette lake and thence northward into the St Lawrence. Evidence in support of this view is twofold, namely, the rock barrier at the western end of Utowana lake and the loose glacial débris dam at the eastern end of Blue Mountain lake. Loose material only separates Utowana and Eagle lakes. Thirty-four marsh and Rock river come to within a half mile of Blue Mountain lake and they are about 20 feet lower than the lake surface, the intervening space being occupied by loose sands and gravels. It would be a simple matter, by shoveling out a trench not over 20 feet deep, to cause Blue Mountain and Eagle lakes to drain eastward. Years ago such an attempt was made but stopped by law. Thus the movement of water here must have been eastward in preglacial time.

That the preglacial drainage through the Utowana lake basin passed westward into the basin now occupied by Raquette lake is certain, there being only loose material across the western end of Utowana lake. From the Raquette lake basin the preglacial drainage was almost certainly southwestward by way of the valleys now occupied by the Fulton chain of lakes. A maximum thickness of less than 100 feet of glacial deposits just north of Eighth lake is all that is necessary to account for the blockade of the southwesterly preglacial channel with resultant ponding of the waters to form Raquette lake. Further evidence for the southwestward course lies in the fact that between Forked lake and Long lake, Raquette river descends more than 100 feet in about 3 miles, mostly by a series of cascades over rock ledges which extend across the narrow channel. Apparently a preglacial divide was situated not far below what is now the outlet of Forked lake, the drift deposits southwest of Raquette lake being sufficient to cause the ponded waters of Raquette and Forked lakes to overflow this divide.

The depression now occupied by Long lake was certainly a preglacial stream channel, and there is also strong evidence that the drainage from this channel passed eastward into the Hudson river rather than northward by way of Raquette river and into the St Lawrence as at present. At Raquette falls, on the river a few miles below the outlet of Long lake, there was a divide with a north-flowing and a south-flowing stream from it. Thus, in preglacial time two streams drained into the depression now occupied by Long

Plate 22



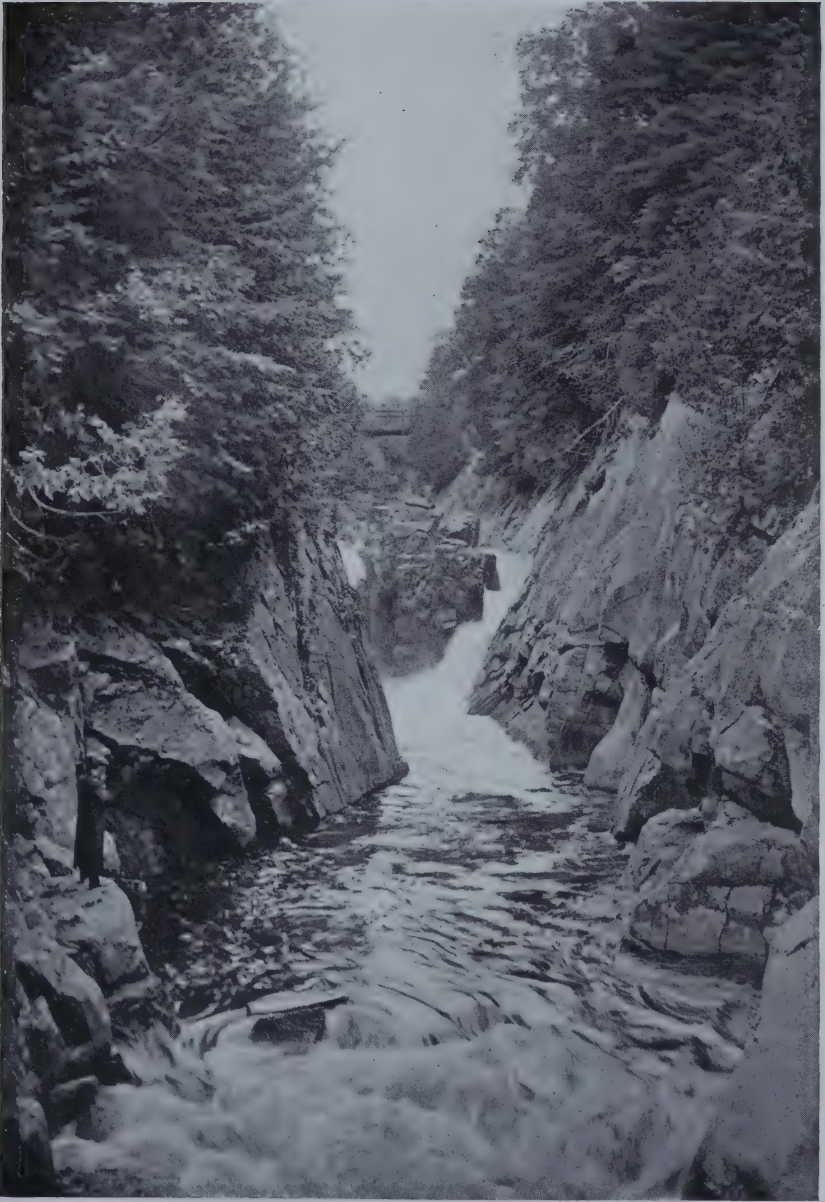
Photograph loaned by J. D. Washer

High Falls of the West Branch Ausable river near Wilmington Notch, Essex county. Height of falls, 50 feet. The river here follows a post-glacial course along a fault zone of weakness in the rock.

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Plate 23



Courtesy of A. Alletag, New York City

The Flume—a gorge through which flows the West Branch of Ausable river 2 miles southwest of Wilmington, Essex county. This gorge has been formed since the Ice Age.

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lake, one north-flowing from the divide near the outlet of Forked lake, and the other south-flowing from the divide at Raquette falls. These streams met to flow eastward into the Hudson river, as Professor Cushing has suggested, either through the Sixmile-Fishing Brook valley in the northeastern part of the Blue Mountain quadrangle, or through the Catlin Lake-Round Pond valley in the southeastern part of the Long Lake quadrangle. In the writer's opinion the best evidence favors the latter channel. Years ago an attempt was actually made to cut a trench through this divide in order to drain Long lake into the Hudson river.

The famous Ausable chasm in Clinton county is a fine illustration of a narrow gorge cut 200 feet deep into Potsdam sandstone by the Ausable river since the Ice Age. The river was deflected from its preglacial channel by a heavy blockade of glacial débris and forced to erode this new channel.

In the Lake Placid quadrangle there is a remarkable gorge known as the Wilmington notch through which flows the West branch of the Ausable river. The south wall of the gorge rises precipitously 600 to 800 feet, while the north wall is more than 1500 feet high and very steep. In preglacial time there was a low divide instead of the notch, with a south-flowing and a north-flowing stream from it. The big glacial lake (see above) which occupied the valley south and southeast of Lake Placid had its waters (known as upper Lake Newman during an earlier stage) held up by the northward retreating ice sheet whose front still filled the Wilmington notch. Further retreat of the ice permitted a lower stage of Lake Newman to connect through the notch with waters in the Wilmington and Keene valleys. During this stage the connecting water flowed southwestward through the notch and into a great lake in the Saranac Lakes valley. With still further retreat of the ice, Lake Newman disappeared; the standing water in the Wilmington valley (Wilmington lake) discharged eastward; and the drainage of that portion of the basin of Lake Newman south and southeast of Lake Placid, where much sediment had accumulated, was northeastward as a stream flowing through the Wilmington notch. Thus was inaugurated the flow, through the notch, of the present stream which, aided by the broken up character of the rocks due to faulting and excessive jointing, has cut a considerable gorge since the Ice Age.

Duration of the Ice Age and time since. Estimates of the duration of the Glacial epoch by the most able students of the subject vary from 500,000 to 1,500,000 years. Such estimates are based

upon amount of erosion and weathering of the earlier glacial deposits in the Mississippi valley, times necessary for the various advances and retreats of the various ice sheets, etc. Thus, from the standpoint of geological history, the Ice Age was of short duration, but, from the standpoint of human history, it was very long.

Estimates of the length of time since the close of the Ice Age are perhaps more satisfactory, though it must be remembered that the close of the Ice Age was not the same for all places. The ice retreated northward very slowly and when, for example, southern New York was free from ice, northern New York was still in the Ice Age. The best estimates for northern New York are based upon the rate of recession of Niagara Falls. The falls came into existence by the plunge of the newly formed river over the limestone cliff at Lewiston, 7 miles below the present falls, immediately after the melting of the ice sheet from that locality. Careful study of all the data has led a number of students of the subject to give estimates of from 8000 to 50,000 years since the ice left the Niagara region, an average being about 25,000 years. Approximately, then, the ice disappeared from the Adirondacks about 20,000 to 30,000 years ago. When we consider the slight amount of weathering and erosion of the latest glacial materials, we are also forced to conclude that the time since the close of the Ice Age in northern New York is to be measured only by some thousands of years. The kames, lake deltas, eskers and moraines have generally been very little affected by erosion since their formation.

Most recent subsidence and elevation. At about the beginning of the Glacial epoch the region of New York State, especially along the eastern side, was much higher than it is today, positive proof for this being afforded by the submerged Hudson river channel which must have been cut when the land was higher. Toward the close of the Ice Age and shortly after the land had subsided to a level even lower than that of today. It was during this time of subsidence that the lower Hudson and St Lawrence channels were submerged and the sea coast was transferred to more nearly its present position. But the land was enough lower than now to allow a narrow arm of the sea (estuary) to extend through the Hudson and Champlain valleys to join a broad arm of the sea which reached up the St Lawrence valley and probably even into the Ontario basin (see figure 15). Beaches, sometimes containing marine shells and bones of walruses and whales, have been found at altitudes of about 400 feet near the southern end of Lake Champlain and 500 feet or more at its northern end. The present altitudes of

these tide-water beach deposits show how much lower the land was during the time of greatest submergence, and that the subsidence was most toward the north.

The most recent movement of the earth's crust over the area of northern New York was the very recent gradual elevation which expelled the tide waters and left the land at its present altitude. The increasing altitudes of the beaches northward prove that the greatest upward movement was on the north. This recent elevation is also clearly registered by the delta sand plains which were formed in the larger glacial lakes of northern New York as, for example, Black lake and Lake Pottersville already described. The delta deposits of these extinct lakes gradually increase in altitude several feet a mile northward.



FIG. 15 The time of the Nipissing Great Lakes and Champlain submergence. The shaded area on the east was covered by sea water.

(After F. B. Taylor)

HUMAN HISTORY AND INDUSTRIES

The Indians

Before the coming of the white man, northern New York was occupied solely by Indians. There is no evidence, however, that the Adirondack wilderness ever had many permanent Indian settlements. Doubtless there were a few more or less well-defined trails through the wilderness, but the great Indian traffic ways between East and West, and North and South, were the low valleys surrounding the Adirondacks.

The Indians which occupied northern, central and much of western New York were known to the French as the "Iroquois," to the English as the "Five Nations," and they were called by themselves "Ho-de-no-sau-nee" meaning the "People of the Long House." The Five Nations constituted an Indian league or confederacy which became very powerful. Comprising the nations of the league were the Mohawks, Oneidas, Onondagas, Cayugas and Senecas, with rather definite property lines separating them. The Mohawks claimed much of the Mohawk valley and all the Adirondack region except a little of the western side which latter came within the territory of the Oneidas. A Canadian tribe of Algonquin descent, however, also claimed the northern portion of the Great Wilderness which slopes off toward the St Lawrence river. This Canadian tribe was derisively known to the Iroquois as the "Adirondacks" meaning "Tree-eaters." The disputed territory was very bloody battleground according to old Indian traditions.

As Sylvester has said: "Among all the Indians of the New World, there were none so politic and intelligent, none so fierce and brave, none with so many germs of heroic virtues mingled with their savage vices, as the true Iroquois — the people of the Five Nations. They were a terror to all the surrounding tribes, whether of their own or of Algonquin speech. In 1650 they overran the country of the Hurons; in 1651 they destroyed the Neutral Nation (on the west); in 1654 they exterminated the Eries (on the west); in 1672 they conquered the Andastes (on the south) and reduced them to the most abject submission. They followed the warpath, and their war cry was heard westward to the Mississippi, and southward to the great gulf. The New England nations, as well as the river tribes along the Hudson, whose warriors trembled at the name of Mohawk, all paid them tribute. The poor Montagnais on the far-off Saguenay would start from their midnight sleep, and run terror-stricken from

their wigwams into the forest when dreaming of the dreadful Iroquois. They were truly the conquerors of the New World, and were justly styled 'the Romans of the West.'"¹

In 1715 the Tuscaroras of the Carolinas joined the Iroquois who then were known as the "Six Nations."

The Adirondack wilderness was one of the greatest of the Indian hunting grounds and called by the Iroquois "Couch-sach-ra-ge." On Pownal's map of the northern British colonies in 1776, the following explanation is written across that portion representing the Great Northern Wilderness: "This Vast Tract of Land, which is the Antient Couchsachrage, one of the Four Beaver Hunting Countries of the Six Nations, is not yet Surveyed." The northern portion of the wilderness was much resorted to by hunting bands of the Adirondack tribes. Old maps show two Indian villages there, probably mostly occupied only during the summer season. One of these was in the vicinity of North Elba just south of Lake Placid, and the other near the Indian carry between Upper Saranac lake and the Raquette river. Traces of this latter village may yet be seen.

Early White Settlers

John Brown's tract. In 1794, James Greenleaf of New York purchased a tract of land containing 210,000 acres on the western slope of the Adirondacks extending from northwestern Hamilton county across northern Herkimer county and into Lewis county. Greenleaf soon mortgaged the property, and in 1798 John Brown [not the John Brown of Harper's Ferry fame] bought the whole tract for \$33,000 at a mortgage sale. In 1799 Brown went to his possessions, made some improvements and established the family of one of his agents on the property. But in 1803 Brown died and the tract was deserted.

About 1812 Herreshoff, who married John Brown's daughter, began a settlement on the tract. "He cleared over two thousand acres, built thirty or forty new buildings, drove in cattle and a flock of three hundred merino sheep. He built a forge and worked a mine of iron ore. He spent his own fortune there and all the money that he could borrow from his friends. But the rugged old wilderness would not be subdued. When he entered the forest he made this declaration to a friend: 'I will settle the tract or settle myself.' He settled himself" (N. B. Sylvester). In 1819, utterly

¹ N. B. Sylvester. Northern New York and the Adirondack Wilderness, 1874, p. 17-18.

discouraged, he killed himself, and the settlement was deserted. Nathaniel Foster and his family lived in the Herreshoff settlement from 1832 for a few years. In 1837 Otis Arnold moved in and raised a large family there.

Number Four, on Beaver lake through which Beaver river flows, is situated in the western part of John Brown's tract, and it is one of the oldest permanent settlements in the Great Wilderness. The first fishing party visited the locality in 1818, and in 1820 Ephraim Craft made a clearing there as first settler. Through efforts of Governor Francis in 1822, ten families settled at Number Four. Many improvements were made, and by 1832 there were seventy-five settlers. But climate, soil and distant markets were against them, so that by 1853 only three families remained.

About 1820, Daniel Smith settled at Stillwater, 12 miles up the river from Number Four. In 1830 he moved still farther up the river to settle at a lake now known as Lake Lila (formerly Smith's lake). He lived a wild hermit's life there for fifteen years.

Lake Bonaparte. Early in the nineteenth century, Count de Chaumont owned several hundred thousand acres in northern New York. In 1815, Joseph Bonaparte, former King of Naples and of Spain and brother of the famous Napoleon, purchased of the Count de Chaumont over 150,000 acres on the western side of the Adirondacks. After his flight to America, Joseph Bonaparte lived in splendor near Bordentown, N. J. In 1828 he built a hunting lodge on Lake Bonaparte within his forest possessions. For several summers he made trips to his property. According to Sylvester: "He went in great state, accompanied by a large retinue of friends and attendants. . . . When on his way, he cut a road through the forest and often went in to his lake in his coach drawn by six horses, with great pomp and ceremony. . . . Upon these excursions he was often accompanied by the friends of his better days, who, like himself, were then in exile. Sometimes in going and returning, he would stop by the wayside to dine under the shade of the primeval pines, and his sumptuous repasts were served on golden dishes with regal splendor." In 1835 he sold his wilderness property.

North Elba and John Brown of Ossawattamie. The vicinity of the present village of North Elba, a few miles south of Lake Placid, has an interesting history. For many years, until the close of colonial days, Adirondack Indian hunting parties made summer homes in that broad valley between the mountains.

Very early in the nineteenth century a number of white families settled in this valley, in the far-off dense wilderness. They called the valley the "Plains of Abraham."

In 1810, McIntyre and several friends from Albany built the North Elba Iron Works which was operated rather unsuccessfully for sixteen years.

But the early settlers had no legal right to their lands, and in 1840 a land speculator forced them out of their homes. Very shortly afterward, Gerrit Smith bought a large tract of land, including North Elba and the Plains of Abraham. His purpose was to settle the lands with free colored people, offering each family forty acres for encouragement. In 1849 Smith made a present of 350 acres to John Brown of Ossawattamie. This land lay on the opposite (western) side of the Ausable river from North Elba. Enthusiastic with the idea of a negro colony, John Brown moved his family into the wilderness. With the help of colored people, he made many improvements in the mountain hamlet. He purposed to make it a home for the persecuted black people, but his colonization scheme was a failure. Though wild in spirit, John Brown was very religious, and had visions of great armies which were to march out to free the slaves. When the Kansas slavery troubles started, he and his sons soon got into the thickest of the fight. So, for nearly ten years or until his execution in 1859, he spent comparatively little time at his Adirondack home. In 1859 he made his famous attempt to free the slaves by force of arms. Failing in his attempt to capture the arsenal at Harper's Ferry, Virginia, he was captured and sentenced to death. Sylvester quotes a writer in "Old and New" for September 1870, as follows: "The house is unpainted and plain, though equal to the ordinary farmhouses of the region. It stands well up the hills, separated from the wilderness by a few cleared fields, commanding a majestic view of the mountain world. A few rods in front, a huge boulder, surrounded by a plain board fence, is the fit monument of the fierce old apostle of liberty. At its foot is the grave. The headstone was brought from an old graveyard in New England, where it stood over the grave of his father, Captain John Brown, who died in New York in 1776. The whole stone is covered with the family inscriptions. . . . Above the little grassy inclosure towers the mighty rock, almost as high as the house, and on its summit is cut in massive granite characters the inscription 'John Brown, 1859.' Standing on top of this monumental rock, for the first time I felt that I comprehended the char-

acter of the man whose name it commemorates. I could well understand how such a man, formed in the mold of the old Scotch Covenanters and English Puritans, brooding over the horrors of slavery, foreseeing the impending struggle for liberty, maddened by the murder of his son and friends in Kansas, with the mighty northern hills looking down upon him, the rush of strong rivers, and the songs of resounding tempests, and the mystery of the illimitable wilderness all about him, should easily come to think himself inspired to descend like a mountain torrent, and sweep the black curse from out the land. I reverently raised my hat, and sung, 'John Brown's body lies a-mouldering in the grave; his soul goes marching on.' "

The John Brown farm is now owned and kept up by the State of New York.

Mines and Quarries.

Adirondack village and Iron Works. One of the most interesting and dramatic chapters in the history of the Adirondacks is that dealing with Adirondack village and the Iron Works. S. R. Stoddard in "The Adirondack" says: "The history of the Adirondack (village) is brief and sad. Messrs. Henderson, McMartin and McIntyre, who, in 1826, owned and operated iron works at North Elba, were shown a piece of ore of remarkable purity by an Indian, which, he said, came from a place where 'water run over dam, me find plenty all same.' The services of the Indian were secured at once, at the rate of two shillings and what tobacco he could use per day, to conduct them to the place spoken of, where they found, as he had said, where the water literally poured over an iron dam. A tract of land embracing the principal ore beds in that vicinity was promptly secured, forges built, and the road cut from the lower works to Lake Champlain. But the expense of transportation to market swallowed up all the profits and the enterprise proved a financial failure. The work, however, was persevered in until the death of Mr Henderson, who was killed in 1845 by the accidental discharge of his pistol."¹ Three years after his death the iron works were abandoned.

Another blast furnace was installed in 1853 but operated only till 1856. A few years ago, after an idleness of nearly sixty years, some thousands of tons of ore were taken out and shipped, via North Creek to the Port Henry blast furnaces in Essex county. Whether mining of the ore is now being carried on, the writer does not know. It is magnetic iron ore and the deposits are extensive.

¹R. S. Stoddard. The Adirondacks, 1893, p. 176-77.

Other iron mines. Aside from the locality just described, there are many places where magnetic iron ores have been more or less mined during the last one hundred years, but only the more important ones are considered.

The greatest iron mines in New York State are in the vicinity of Port Henry, Essex county. Of these the oldest is what is now called the Cheever mine (north of Port Henry) which was first worked late in the eighteenth century. But still greater ore deposits, known as early as 1835-40, are at Mineville, 6 miles northwest of Port Henry, where two companies own property. All the mines mentioned are now in operation, their total production to date being no less than 25,000,000 tons. The ores are crushed and then concentrated by a magnetic separation process. They are very pure and of high grade. Approximately 1,000,000 tons a year are now taken out.

In the vicinity of Hammondville, Essex county, are other considerable iron ore mines, the first of which was worked in 1824. These mines were most active from 1873 to 1890, ceasing to operate in 1893. About 2,000,000 tons of ore have been taken out.

In southern Clinton county (near Ausable Forks) there are several magnetic iron ore deposits, especially the Arnold Hill and Palmer Hill mines, the former having been intermittently worked from 1806 to 1906, and the latter between 1825 and 1890. Altogether about 2,000,000 tons of ore have been removed.

The Lyon Mountain magnetic iron ore mines are situated near Dannemora in Clinton county. Mining began there in 1871, and still continues very actively. The ores are extensive and of high grade. Approximately 4,000,000 tons of ore have been mined.

Though early known, systematic operations did not begin at the Benson Mines in southern St Lawrence county till 1889. Work has been rather intermittent since then. Several hundred thousand tons of ore have been removed.

Graphite mines. As already stated, flakes of graphite (so-called "black lead") are of common occurrence in certain strata of Grenville age. At several localities much graphite has been mined.

By far the most important mine is that owned and now operated by the Joseph Dixon Crucible Company at the village of Graphite in Warren county. A hard quartzite rock, distinctly stratified in relatively thin layers, contains the graphite. This rock is mined by underground methods, crushed, and the flakes of graphite separated by mechanical means. This is one of the most important graphite

mines in America, and has been in operation many years. It produces two to three million pounds a year.

Several smaller mines have been operated from time to time in Essex, Warren and Saratoga counties.

Garnet mines. Since 1882, garnet for abrasive purposes has been mined in northwestern Warren county. It is the common red garnet used to manufacture garnet paper and cloth instead of ordinary quartz sandpaper. The oldest working is the Rogers mine on Gore mountain where the numerous garnets are from an inch to a foot or more in diameter, embedded in a gray rock. The work is all done by hand.

The North River Garnet Company has a large mine in operation on Thirteenth lake. There the garnets are smaller but the production larger. The rock containing them is crushed, and the crushed garnet is removed by machinery.

The total output of the garnet mines is several thousand tons a year.

Stone quarries. Building stones of excellent quality are exceedingly abundant in the Adirondacks. Whole mountains are commonly made up of such materials, especially granite, syenite and anorthosite. Because of lack of transportation facilities and distance from markets, these stones have been quarried at very few localities except for local use. Some of the principal stone quarries are as follows: granite, syenite and anorthosite near Ausable Forks; anorthosite near Keeseville; and granite near Dannemora. Considerable shipments are made from these places.

Green marble (so-called verde antique) of Grenville age was formerly quarried near Thurman, Warren county, and in the vicinity of Port Henry, Essex county.

Forests and Lumbering

Much of the Adirondack region is heavily wooded, though very little of the virgin forest now remains. "By far the greater part of the forest is of deciduous growth, about 20 per cent only of the trees being conifers. Of the deciduous trees, the most common species are the maple, birch and beech, with their varieties. Next in the order of quantity, come the poplar, ash, cherry, ironwood, basswood, willow, elm, red oak, butternut, sycamore and chestnut. The smaller species of trees or shrubs are represented by the mountain ash, alder, mountain maple, elder, striped, dogwood, shadbush, sumach and 'witch-hopple.' The chestnut is very rare throughout the Adirondack plateau; although growing close to the foot of the



H. P. Cushing, photo

A general view, looking south from southern Franklin county into northern Hamilton county, illustrating the densely wooded character of the Adirondack region

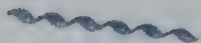
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Densely forested mountains near Saranac lake in the northern Adirondacks
Courtesy of the New York Central Lines

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hills, it disappears on the higher altitudes of the Great Forest. For the same reason the oaks are rare and stunted. Among the conifers are found the spruce, hemlock, balsam, tamarack and white cedar. Some white pine of original growth remains, but this noble tree, which once grew thickly throughout the whole region, is now limited to a few small patches of inferior quality.”¹

The principal commercial soft woods are spruce, balsam, pine and tamarack (larch), and the principal hard woods are birch, beech, maple and cherry.

When a tract of land has been “lumbered over” this does not necessarily mean that all trees of considerable size have been removed. In by far most cases, the method is to “lumber” a district for certain kinds of trees. Thus, a tract of land may be “lumbered over” for certain soft woods, later for certain hard woods, and again for other soft woods or even for a second growth of soft woods. If, for example, the spruce has been cut, a new growth of marketable size is looked for in about fifteen or twenty years. Twenty years after going over a tract of land for spruce, the casual observer would scarcely know that the tract had been “lumbered.”

Much of the Adirondack region is now owned by the State and, according to the present law, lumbering operations are not allowed on state lands. The time should soon come when certain mature trees can be removed from the state forests, thus allowing the benefit of the use of such trees without injury to the forests themselves.

In the Adirondacks, the usual method of lumbering is to cut the logs into lengths of $13\frac{1}{2}$ feet and drag them into great piles in the woods. When the snow is deep enough, the logs are usually moved from the woods in big loads on runners. Some are taken to local sawmills, but most of them are dumped into certain streams. In some cases the logs are sent down the mountain sides to the streams through chutes or flumes. During the spring, when the ice has gone out and the water is high, the logs are “driven” downstream, often for many miles, to saw, pulp and paper mills. Each company has its own mark stamped into the end of each of its logs to serve as a means of identification. Logs are thus “driven” down nearly all the principal Adirondack streams. The “log-drivers” often become very expert, and their profession is one of the most characteristic of the woods and is well paid. Large reservoirs are commonly constructed for the purpose of rushing a big volume of water

¹ New York Forest Commission, 1891, p. 103.

down stream in a short time to facilitate the transit of the logs. Sometimes thousands of logs form great "jams" against obstacles in the streams, and much labor is required to break up such "jams."

Forest fires have wrought havoc in the Adirondacks. Hundreds of square miles have been burned over, often leaving nothing of value. In such cases, a second growth of any use requires many years. In certain severe fires, forested mountains have been so thoroughly denuded that even the sod has been consumed, leaving nothing but mountains of barren rocks. One of the most severe fires of this kind in recent years devastated many square miles in the vicinity of Long Lake West on the Adirondack Division of the New York Central Railroad in 1908. Shortly after this great fire, the State adopted a system of fire watchmen on various prominent peaks throughout the Adirondacks. During the season when fires are likely, these watchmen, supplied with maps, field glasses and telephone, scan the forests in all directions. Immediately upon the discovery of a fire, the nearest fire warden, notified by telephone, goes out, with assistants if necessary, to fight the fire. Since this plan has been adopted, disastrous fires have been very notably reduced.



Courtesy of Warwick Carpenter, Albany, N. Y.

A view in the virgin forest near West Canada lake in the southern Adirondacks

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Courtesy of Warwick Carpenter, Albany, N. Y.

Lumberman's refuse which becomes tinder for a forest fire

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Courtesy of Warwick Carpenter, Albany, N. Y.

A scene of desolation where dense woods have been ravaged by a forest fire

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Plate 29



Courtesy of the New York Central Lines

Road through an Adirondack pine forest

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Plate 30



Courtesy of the New York Central Lines

Adirondack white birches

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APPENDIX

SOME COMMON ADIRONDACK MINERALS

A *mineral* is a homogeneous, natural substance with a definite chemical composition, and usually in solid form. Nearly a thousand well-defined species are known.

A *crystal* is a mineral with a regular external form bounded by plane faces and possessing a definite internal structure. Crystals commonly develop from ordinary solutions or during the cooling of molten masses of rock.

Mineral cleavage is the tendency of certain minerals to break along more or less smooth, plane surfaces in one or more directions.

Amphibole. Crystals usually in short stout prisms, the prismatic faces meeting at 124 degrees. Two good cleavages at 124 degrees. Color commonly brown to black, but sometimes white or green. Some varieties can just be scratched by a knife, others can not. *Hornblende*, the most common variety, is a silicate of lime, magnesia, iron, aluminum etc., and is dark colored. *Tremolite* is a silicate of lime and magnesia, and is white.

Hornblende is very abundant in the Adirondack region, being a prominent constituent of the syenite-granite series; some dark phases of the anorthosite; gabbro; and many of the Grenville gneisses. Well-formed crystals are not common. Tremolite is much rarer, but occurs locally in certain Grenville strata, especially those associated with limestone.

Apatite. Crystals are hexagonal prisms capped by six-sided pyramids. Just hard enough to scratch glass. No good cleavage. Color, greenish, bluish green or brown. Composition, a phosphate of lime.

Well-formed microscopic crystals are common in the Adirondack igneous rocks and in certain of the Grenville gneisses. Locally, crystals from a fraction of an inch to several inches long are developed in the Grenville limestone.

Asbestos. See serpentine.

Augite. See pyroxene.

Biotite. See mica.

Calcite. Commonly called "calc-spar." Crystals show many variations, though all have a threefold development such as three-sided prisms, pyramids or rhombohedrons. Very perfect cleavage in three directions yielding fragments with faces which meet at 105° and 75° . Color, white when pure. Relatively soft, can be scratched with a copper coin. Composition, carbonate of lime.

Calcite is the chief constituent of the Grenville limestone, generally making 75 to 95 per cent of the mass and is therefore very abundant in the Adirondacks.

Chalcopyrite. Commonly called "copper pyrites." Rarely in crystals. No cleavage. Color, deep brass-yellow. Relatively soft, can be scratched by a copper coin. Composition, sulphide of copper and iron.

Fairly widespread as a very minor constituent of the anorthosite and often clearly visible to the naked eye.

Coccolite. See pyroxene.

Feldspar. There are several important varieties of feldspar with certain features in common as follows: two well-defined cleavages at or near 90° ; scratched by quartz or flint but not by a knife; crystals in prismatic forms usually making angles of 120° ; composition, silicate of aluminum with potash, soda or lime. Color, white, pink, or greenish gray. *Orthoclase* is a white to pinkish potash feldspar with two cleavages at exactly 90° . *Microcline* is much like orthoclase except for cleavages at $89^{\circ} 30'$ and crossed striations when viewed as a thin slice under the microscope. *Albite* is a white soda feldspar with cleavages at $86^{\circ} 24'$. *Oligoclase* is a greenish white soda-lime feldspar with cleavages at $86^{\circ} 32'$. *Labradorite* is a greenish gray to dark gray lime-soda feldspar with cleavages at $86^{\circ} 4'$, and it sometimes exhibits a play of colors on one cleavage face. *Anorthite* is a white lime feldspar with cleavages at $85^{\circ} 50'$. *Plagioclase* includes albite, oligoclase, labradorite and anorthite, and these nearly always exhibit well-defined striations on one of the cleavage faces.

Orthoclase is a very prominent constituent of the syenite-granite series and pegmatite, but is rare in the other igneous rocks. It is common in many of the Grenville gneisses. Albite and anorthite seem to be uncommon in the Adirondacks. Microcline and oligoclase in smaller amounts generally accompany orthoclase. Labradorite is the chief constituent of the anorthosite, gabbro and diabase. It also occurs in some of the Grenville gneisses.

Garnet. Exists in several varieties differing in color and composition. Most common in the Adirondacks is *almandite* garnet

which often occurs as good, very symmetrical crystals with twelve or twenty-four faces or a combination of the two. Hardness, greater than that of quartz or flint; color, red to reddish brown; very brittle; and only imperfect cleavage. Almandite is a silicate of aluminum and iron.

Garnet occurs as an accessory mineral in many Adirondack formations. In some phases of the anorthosite, syenite-granite and gabbro, it is often clearly visible to the naked eye. Some of the Grenville gneisses are rich in garnets, individual crystalline masses frequently attaining diameters from an inch to a foot or more in certain hornblende gneisses as, for example, at the garnet mines near North Creek and at Thirteenth lake in Warren county.

Graphite. Often called "black lead." Seldom appears as good crystals, but nearly always as thin, shiny-black, flexible flakes with one almost perfect cleavage. It is opaque, easily scratched by the finger nail, and leaves a black mark on paper. Composition, pure carbon.

Certain of the Grenville gneisses, schists and quartzites, and most of the limestone contain graphite in clearly visible flakes in amounts up to 10 or 12 per cent. Rarely, small veins of graphite have been found. Graphite-rich schists are mined on a large scale for the mineral at the village of Graphite in northeastern Warren county. Smaller mines have been operated in other parts of Warren county and in Saratoga county. Small masses of graphite have occasionally been noted in pegmatite. Good six-sided tabular crystals may sometimes be seen in the limestone.

Hornblende. See amphibole.

Hypersthene. See pyroxene.

Ilmenite. Commonly called "Titanic iron ore." It is an oxide of iron and titanium. Seldom in well-defined three or six-sided thick tabular crystals. In many respects much like magnetite (see below), but it is only slightly magnetic and gives the chemical test for titanium.

Ilmenite occurs in small amounts as scattering grains in most of the Adirondack igneous rocks, but at Lake Sanford, Essex county, there are tremendous deposits of this mineral.

Limonite. This is a hydrous oxide of iron commonly called "bog iron ore." Many of the Adirondack rocks, when weathered, show brown or yellowish brown colors due to the presence of limonite which has formed during the decomposition of iron-bearing minerals. Thus the typical, fresh, greenish gray syenite often has a brown outer zone.

Magnetite. This mineral, commonly called "magnetic iron ore," is one of the oxides of iron. Often found in good crystals, either regular octahedra or dodecahedra forms, but more often as irregular grains. It is black, with a metallic luster; about as hard as steel; and strongly attracted by the magnet. Generally closely resembles ilmenite (see above).

Magnetite is widespread throughout the Adirondacks, being found as scattering grains in the anorthosite, syenite-granite, gabbro and diabase, as well as in some of the Grenville gneisses. Locally, the magnetite makes up extensive ore bodies, as at Mineville, Essex county, and at Lyon Mountain, Clinton county.

Mica. This is a family name including several important members, all of which possess a very perfect cleavage in one direction whereby the mineral peels off in exceedingly thin layers. Mica most often appears as thin flakes scattered through rocks, but sometimes in good six-sided tabular to prismatic crystals. All micas are silicates of aluminum, and all are relatively soft, being easily scratched by a copper coin.

Muscovite is a potash mica, transparent in thin sheets. It occurs in relatively large masses in some of the pegmatite, and in small, shiny flakes in certain Grenville gneisses and quartzites.

Biotite is an iron-magnesia mica, dark colored but translucent in thin sheets. As small flakes it often occurs in many types of the Adirondack rocks and in certain of the Grenville gneisses.

Phlogopite is a magnesia mica, brown and translucent in thin layers. It occurs only in certain Grenville gneisses, schists, quartzites and limestones.

Microcline. See feldspar.

Muscovite. See mica.

Orthoclase. See feldspar.

Phlogopite. See mica.

Pyrite. Usually known as "iron pyrites" or "fools gold." It often shows good crystal forms as cubes, octahedrons, pyritohedrons, or combinations of these. It is a sulphide of iron; scratched by quartz but not by a knife; of pale brass-yellow color with a metallic lustre; very brittle; and has practically no cleavage.

Pyrite occurs, in small amounts, as irregular grains or specks in anorthosite, gabbro, diabase, and certain of the Grenville gneisses and schists.

Pyroxene. This is a family name including, in the Adirondacks, *augite*, (a silicate of magnesia, lime, aluminum and iron); *hypersthene* (a silicate of magnesia and iron); and *coccolite* (a silicate

of lime and iron). All these have two fairly well-defined cleavages meeting at nearly 90° . Augite and hypersthene are dark green to black and usually in good crystalline forms difficult to distinguish (without the microscope) from hornblende except by differences in cleavage directions. Augite is common in the anorthosite, syenite-granite, gabbro and diabase. Hypersthene is rare except in the gabbro, anorthosite and diabase. Coccoilite (or hedenbergite) is a grayish green pyroxene abundant in certain Grenville gneisses.

Pyrrhotite. Commonly called "magnetic pyrites." It is a sulphide of iron somewhat like pyrite, but is softer than a knife, has a bronze color, and it attracted by the magnet.

It exists as small scattering grains in certain Grenville limestones and gneisses, and in the anorthosite.

Quartz. This very common mineral is an oxide of silicon which often crystallizes in characteristic hexagonal prisms capped by six-sided pyramids. It is notably harder than steel; clear and glassy looking when pure; very brittle; and without cleavage.

It is very abundant as distinctly visible grains in all the granites and most of the syenites and pegmatites of the Adirondacks. It also largely constitutes the Grenville quartzites and is prominent in many of the lighter colored Grenville gneisses and limestones.

Serpentine. A dull green to yellowish green mineral usually in irregular massive form. Never crystallized. It is a hydrous silicate of magnesia with a greasy luster and is easily scratched by a knife. A fibrous variety is known as serpentine *asbestos* which is rarely found in small veins in Grenville limestone as near Thurman P. O. in Warren county.

Serpentine at times occurs in considerable quantity in the Grenville limestone, causing the rock to have a grayish green or mottled green and white appearance. Such rock is variously called "serpentine marble," "ophicalcite," or "verde antique," the serpentine having resulted from the chemical alteration of pyroxene in the limestone. Such serpentine marble has been quarried at several localities in Warren and Essex counties.

Tourmaline. The chemical composition of this mineral is very complex, it being a silicate of baron and various metals. It often appears in good prismatic crystals which are usually triangular or with faces in multiples of three. It is transparent to opaque; harder than quartz or flint; without good cleavage; and, in the Adirondacks, is nearly always either black or brown.

Black tourmaline crystals, from a fraction of an inch to several inches long, are fairly common in the coarse grained pegmatite

dikes. Brown tourmaline in small crystals may sometimes be seen in the Grenville limestone.

Tremolite. See amphibole.

Zircon. This is a silicate of zirconium harder than quartz or flint; of brown color; without good cleavage; and usually crystallized as four-sided prisms capped by four-sided pyramids.

Crystals up to one-half of an inch long are rarely seen in the pegmatite. Microscopic crystals are nearly always present in small amounts in the anorthosite, syenite-granite and gabbro.

There are, of course, many other minerals which are very rare or only locally developed in the Adirondack region, but the above list includes about all that are commonly met. Anyone further interested in the recognition of Adirondack minerals should consult some good book on mineralogy.

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New York State Museum

JOHN M. CLARKE, Director

POSTGLACIAL FEATURES OF THE UPPER HUDSON VALLEY

BY

H. L. FAIRCHILD

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*The University of the State of New York
Department of Science, March 8, 1917*

*Dr John H. Finley
President of the University*

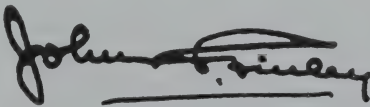
SIR:

I beg to communicate herewith and to recommend for publication as a bulletin of the State Museum the accompanying manuscript entitled " Postglacial Features of the Upper Hudson Valley," which has been prepared by Prof. Herman Leroy Fairchild, geologist.

Very respectfully yours
JOHN M. CLARKE
Director

THE UNIVERSITY OF THE STATE OF NEW YORK
OFFICE OF THE PRESIDENT

Approved for publication this 12th day of March, 1917

A handwritten signature in dark ink, reading "John H. Finley". The signature is written in a cursive style with a horizontal line underneath the name.

President of the University

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POSTGLACIAL FEATURES OF THE UPPER HUDSON VALLEY

By

H. L. FAIRCHILD

INTRODUCTION

This area, comprising the five quadrangles, Glens Falls, Saratoga, Schuylerville, Schenectady and Cohoes, is the most typical section of the Hudson valley Pleistocene. It received the heaviest contributory drainage of Glacial time; it holds the most extensive detrital plains, the vast deltas built by the inflowing streams; and abundant evidences of the deep submergence in sea-level waters following the recession of the latest ice sheet. Other interesting features are the abandoned distributary channels of the glacial predecessor of the Mohawk, and three lakes of singular character. In recent years the area has been described in a general way by Prof. J. B. Woodworth (see no. 4 of the appended Bibliography); Prof. W. J. Miller has referred to the Glacial course of the Hudson river through the Kayaderosseras valley (6), which was noted in 1895 by G. F. Wright (2); and Professor Stoller has published a description of the glacial geology of the Schenectady quadrangle (7).

The original purpose of the present writer was merely to show the true character of the peculiar basins of Round and Saratoga lakes, but this is so tied in with other interesting matters of the Pleistocene geology of the region that the brief paper has been given a general character.

GLACIAL DRAINAGE

The present streams which enter this section of the Hudson valley are the much diminished successors of the swollen glacial rivers which swept an enormous amount of detritus into the valley. In the northern part of the area the chief inflow from the east is the Batten kill, and on the west the upper Hudson. During later glacial time, while the ice margin lay against Luzerne and Palmertown mountains, west of Glens Falls, the upper Hudson flow was forced south, at Corinth, through the valley of present Kayaderosseras creek, noted by Wright in 1895 (2, page 674). The great sand plain north of Ballston Spa was built as the delta of the glacial Hudson in the waters at marine level, which now has a summit altitude here of 380 feet. The plain is now at 400 feet. When the ice lobe receded from the face of Palmertown mountain the Hudson found its present course through the narrow defile cutting the Luzerne mountains. The first flow must have been only just below its previous channel at South Corinth, which is now 640 feet. The east face of Palmertown mountain must have been swept by the river from 640 feet down to the sea-level waters, at 440 feet. Fine bars at 440 feet lie close to the east face of the mountain, clearly attesting later wave work. As pointed out by Woodworth, the early Hudson flow past Palmertown mountain produced the sand plains southward at Fortsville and toward Gansevoort (4, pages 144-49). Ice blocks buried in the glacial and delta gravels west of Fortsville have produced the numerous kettles and lake basins.

As the ice margin backed away, northward, the river poured its burden of detritus freely over the plain and built the extensive sand plains eastward toward Fort Edward and northeastward toward Glens Falls. The strong terracing with bold fronts exhibits the effects of the slow rise of the district out of the marine-level waters.

In the central part of the map area the Kayaderosseras creek became the successor of the early Hudson river and must have contributed to the building of the lower sand plains on the west side of the broad valley in the neighborhood of Ballston Spa.

In the southern part of the area the Hoosic river was always the large contributor from the east. But the great flood poured in from the west. The largest of all the glacial rivers that entered the Hudson valley was the predecessor of the present Mohawk, named the Glaciomohawk and the Iromohawk (10, page 38). For a very long time, probably many thousand years the latter river

was the predecessor of the St Lawrence and rivaled it in volume, for it bore not only the drainage of the Great Lakes but the copious waters from a great stretch of the melting front of the Labradorian glacier. This river had a complex relation to the Hudson valley which will be considered later in this writing.

DELTA SAND PLAINS

Fully one-half of the area described in this paper is buried under the deluge of detrital deposits that were laid down in the sea-level waters that followed and continuously laved the receding front of the latest ice sheet. The more conspicuous, level stretches which would be evidence to even the casual observer of deposition in standing water are indicated by purple shading on the map. The shore lines of the summit level of the marine waters are marked by the heavy, broken lines. It must be understood that all the breadth of the great valley was submerged by the waters, up to the plane as shown by the isobasal lines, in solid brown. Large tracts not marked in color received much deposit of sand, silt or clay.

The uplifted marine plane is now 355 feet above tide at Schenectady, 400 feet at Saratoga Springs, and 440 feet at Glens Falls. As indicated by the isobases, the direction of greatest differential uplift or tilting is 20 degrees east of north. The average deformation of the tilted plane in the distance of 50 miles between the 350 and the 475 feet isobases is 2.5 feet a mile, the rate increasing slowly northward. On the meridian the gradient is 2.2 feet.

The extensive sand plains, making the profusion of purple color on the map, were mostly subaqueous, only occasionally marking the highest water level, or rising slightly above. They were all swept by the relatively falling waters. This is an important distinction, because many students make the mistake of regarding the highest, broad and conspicuous plain of some particular locality as the summit water level, while in fact it may be far inferior. The sand plain southwest of Schenectady is full height, lying near the eroded head of the Iromohawk delta. The plain at Malta, north of Round lake, was strongly swept by storm waters. The desertlike plain north of Ballston Spa is about 10 feet over the marine plain, and was the delta of a powerful stream, the glacial Hudson, with later contribution by the Glaciomohawk and the Iromohawk. Some of the plains west and northwest of Glens Falls are at or above the summit of the sea-level waters. In the latter district the deposits made in

sea-level waters grade up into those made in glacial waters, and close discrimination has not yet been attempted. A large glacial lake occupied the basin of Lake George and the district south of French mountain, with its outlet along the east face of Luzerne mountain. The group of lakes south of French mountain occupy ice-block kettles in a stretch of kame-moraine that was built at the border of the ice lobe which blocked the Lake George valley. The sea-level waters entered Lake George basin through the pass east of French mountain. The kettles have been mapped by Woodworth (4, plate 14).

The Hoosic delta has been described by Woodworth (4, pages 134, 200, plate 10). Professor Stoller has mapped the northern part of the Schenectady delta (7), and the present writer has mapped the southern part (14, plate 6).

SUMMIT SHORE LINE

Abundant phenomena mark the highest stand of the waters; being the ordinary shore-line features, gravel bars, cliffs and deltas. The beach phenomena, gravel bars and wave-cut cliffs, are not commonly conspicuous, as they require for strong development a combination of conditions, and usually the summit waters along the sides of the valley were either too shallow, too secluded, or without sufficient coarse material for bar-building. A few good gravel embankments are indicated on the map. A splendid summit-level bar lies 5 miles southeast of Fort Edward and $2\frac{1}{2}$ miles south of Durkeetown. North of this great gravel bar, which carries a ridge road, are several fine erosion cliffs at inferior levels. The lowest cliffs and terraces, a mile south of Durkeetown, with an altitude of 300 down to 260 feet, Woodworth took as the summit water level (4, page 138, plate 12). The big bar is 425 feet above tide and is over 10 feet below the theoretic summit level. The hills in this district are Cambrian black slates, with northeast-southwest shaping due to ice molding. They are rocdrumlins. Below the summit marine plane the west exposure sides are swept clean and faceted by wave work, with prevailing horizontal lines. Above about 440 feet, or 450 at North Argyle, the surface has an aspersity or roughness quite wanting below.

Another group of rocdrumlins lies east and northeast of Saratoga lake, also noted by Cushing (8, page 14). The northern hills of this group, near Fish creek, stood as islands in the sea-level waters and

show characteristic wave work. A few cliffs that have been seen are indicated on the map.

Three miles northwest of Mechanicville a heavy bar lies at four corners, at the summit level for that place, 390 feet. Many beach features, of which two cliffs are noted on the map, are seen northward.

On the west side of the valley one of the most important and conspicuous beaches is found on the Glens Falls quadrangle, at the mouth of the Hudson gorge and close to the east face of Palmertown mountain. The Hudson delta at this locality has already been noted. It was partly mapped by Woodworth (4, plate 13, page 144). He maps the higher terrace as glacial. But three strong gravel bars on the edge of the high terrace are positive evidence of open-water wave work. The theoretic height of the marine plane is here 435 to 440 feet. According to the map contours, the upper of the heavy bars is 440 feet. The lowest bar lies under the house of Mr Richard Denton, at the end of the short road, at about 420 feet altitude. This beach continues south for over a mile, to the next crossroad.

Some fine bars and cliffs, somewhat below the summit plane, occur east and north of Glens Falls. A mile northeast of Wilton, and southeast of Mount McGregor, is a drumlin with bars across the top at over 400 feet, the theoretic plane being there 420 to 425 feet.

West and northwest of Saratoga the shore line is marked by numerous cliffs, bare ledges and weak bars or spits, which are not indicated on the map. One of the bare-rock spaces is the "Cryptozoon Ledge," which has been made state property in care of the State Museum.

The writer has not systematically examined the shore lines continuously, but has found good beaches and shore features at numerous points, amply sufficient to determine positively the initial water level from New York City to Canada. It should be emphasized that the absence of features expected at any locality, or even along a considerable stretch of shore line, is not conclusive negative evidence. Shore features are capricious and often lacking where most confidently expected and where the fact of standing water is proved by good features on both sides of the negative locality. On the other hand, strong features are sometimes discovered where not expected.

There are several reasons for the weakness of the summit features, besides those already mentioned. The waters soon fell away from the initial or summit plane, due to the rising of the land. The amount of detritus in the grasp of the earliest water was relatively

small. Time was not allowed for the cutting of cliffs and building of bars except in the most favorable localities. At lower stands of the water the detritus was accumulated by the rinsing down of the upper slopes.

The boundaries of the summit level as indicated in the map will be a guide for more careful and detailed study, which will certainly reveal many very interesting features.

HUDSON-CHAMPLAIN DIVIDE

The divide between the Hudson and Champlain valleys is of significance in this study since it has been regarded as the outlet of glacial Champlain waters, and hence interpreted as a river channel.

The divide is indefinite and complex. The separation of drainage is at Dunham basin, 3 miles northeast of Fort Edward, with altitude of about 150 feet, but this place is only part of a level, silted stretch some 12 miles long, between Fort Edward and Fort Ann. It was described in 1894 by S. P. Baldwin as follows:

The lowest divide is that crossed by the canal from Whitehall to Fort Edward at 150 feet, at the same height as the ends of the canal, Fort Edward and Whitehall. A continuous sand plain extends from one place to the other, and is so nearly level that while the divide is really at Fort Ann, 11 miles from Fort Edward, yet the canal flows toward Whitehall, except the last 3 miles near Fort Edward. . . . The two valleys narrow rapidly to Fort Ann, where is seen a typical divide between streams, entirely of rock, showing little evidence of glacial or postglacial erosion, and not at all resembling a river channel. It is not probable that any large stream ever flowed across this divide for more than a very short time. (1, page 178)

In 1895 G. F. Wright described the valley:

Another remarkable channel extends from Fort Edward to Whitehall. This is followed by the Champlain canal, whose summit level is 142 feet above tide. This valley is about a mile in width between Fort Edward and Fort Ann, a distance of about 12 miles, and is occupied most of the way by swamps. Between these places the canal occupies a dead level. On the west side, toward Sandy Hill and Glens Falls, this is bordered by a sharp margin of sand and gravel deposits at a level of about 300 feet. The eastern side of the Fort Edward-Fort Ann valley is bounded by low slate hills flanked up to about 200 feet above tide, or 50 feet above the valley, with deposits of Champlain clay. At Dunham's basin, 2 miles above Fort Edward, however, the channel divides, one branch going east of a low slate hill and entering the Hudson a few miles below Fort Edward. (2, page 674)

These two quotations and a glance at the topographic map should satisfy the reader that this valley was not the path of any post-glacial river. It has none of the typical features of a river channel, and no correlating delta. The sand plains at Hudson Falls were built into the valley by the Hudson flow and show constructional

not erosional, fronts; and since the building of the lower sand plains there has been no great erosion of the valley.

The valley was drowned under 300 feet of water as the ice uncovered it. As the land slowly rose out of the waters the land drainage and wave action on the slopes rinsed some detritus down to the valley bottom. When the water was very shallow, forming a strait in the valley, and so connecting the deeper waters at the two ends, storm waters were driven in both directions, which may account for the level character of the valley bottom. It is possible that during a low stage of the falling waters the southward current helped to smooth the divide. The bare shale rocks alongside the valley, and rising as knolls in the bottom of the valley, have forms chiefly due to wave action, not definite stream work.

Similar explanation must be made for two other supposed river channels, one of which is the "Coveville," west of Schuylerville; another is the "Quaker Springs scourway," a few miles south. No effective stream flow occurred at either locality, but chiefly the work of static waters. The features are mainly the product of delta construction and wave erosion in subsiding waters. At the time when the standing waters were lowered (relative to the land) to what is now 200 feet the southward current, the initial Hudson river, probably scoured the depression northwest of Coveville. But this was not sufficient to direct the flow of Fish creek. The Quaker Springs tract comprises the deltas of several small streams, with leveling by waves. The area is mostly sand, declining eastward, toward the axis of the valley. Much of the sloping surface is rolling and dunny. The front of the plain, facing the river, is bare shale which has been rinsed clear of the drift and sand by wave erosion. Looking east, across the Hudson, one sees a beautiful series of terraces, at all levels from 140 feet up to nearly 400 feet. The evidence of long-lived, standing waters as the latest occupant of the region is conspicuous and conclusive. There are no distinct channel characters and no relation of topographic or other features requiring a channel; no evidence of an ice border, or any ice contact; and no corresponding features on the opposite side of the Hudson.

IROMOHAWK DISTRIBUTARIES

The marine plane at Schenectady is uplifted to 355 feet altitude. The great delta sand plain, stretching from Schenectady to Albany, 12 miles, was laid in the sea-level water at practically full height.

A copious flow with abundant detritus passed out of the Mohawk valley at an early stage of the ice removal, and long before the land uplifting began in the Albany district. In the series of maps prepared by the writer to show the waning of the Labradorian ice sheet from New York State and the correlating waters (11, 14), the Albany district is represented as ice-free and flooded by the Hudson estuary long before the flood of the Great Lakes passed out through the Mohawk valley. It seems quite certain that the uplifting at Albany did not begin until the outflow of the Great Lakes area found escape through Lake Iroquois and the Iromohawk river, and the Schenectady-Albany delta had received its main deposit. At this time the head of the Iromohawk, at or near Rome, had an altitude above sea of not over 110 feet.

The apex or head of the delta was west of Schenectady and remnants of it are now found in coarse cobble deposits above and below Rotterdam Junction.

When the wave of land uplift, subsequent to the removal of the ice sheet, in its northward progress reached the Albany district, the upper part of the Schenectady delta was lifted above the Hudson estuary waters and the Iromohawk river was obstructed by its own deposits. Previously the currents had swept southeast toward Albany, but with the excessive rise of the delta the river flow was diverted to the northern side of the delta, on the side of belated or lesser uplift. The river channel was extended northward through what is now Ballston lake toward Ballston Spa and Saratoga Springs. This diversion has been recognized by Stoller (7, pages 30-31), who thinks that the present channel of the Mohawk, southeast of Rexford Flats and Aqueduct, carried a portion of the flow from the earliest diversion. At East Line (see map) the northward coursing Iromohawk was divided into three distributaries, first noted by Stoller (7, page 32). One, in northward course to Ballston Spa he called the Mourning Kill channel; the second, the Drummond channel, led northeast toward the site of Saratoga lake, which was then occupied by a huge, detached ice block. The third channel, which we call the Maltaville channel, led southeast toward Mechanicville, passing the site of Round lake, which was also occupied by a mass of ice. The Round lake problem is discussed in a later chapter.

The two distributaries first noted made contribution to the lower sand plains at Saratoga Springs and west and southwest of Saratoga lake. The Maltaville river swept its detritus past the Round Lake ice block and dropped it in the neighborhood of Mechanicville. The

elevated sand plain north of Ballston Spa was built somewhat earlier by the glacial Hudson through the Kayaderosseras valley. From study of the Pleistocene waters in their relation to the land uplift the writer believes that the Hudson was in its work of delta-building at Glens Falls when the Iromohawk was forming the lower Saratoga plains.

EFFECT OF LAND TILTING

It has been stated that the Iromohawk was diverted into northward flow, toward Saratoga, by the obstruction of its own delta deposits on the south and east, as the latter were lifted out of the marine waters. Probably there was another cause. It appears that the land uplift was by a wave movement, progressive from south to north, subsequent to the removal of the ice from the rising district, from which it would appear that the uplifting at Saratoga to equality with Schenectady was somewhat tardy. This difference in height would be small, in the 18 miles, but might have some effect. The chief and unquestioned factor, however, is the differential uplift. The gradient of the uplifted marine plane is in this district 2.4 feet a mile. This makes a difference between Alplaus, the point of latest diversion, and East Line, the point of trifurcation of the river, of 22 feet. This means that East Line was originally 22 feet lower relative to Alplaus than it is today. Saratoga was 100 feet lower than Schenectady, and now, after the tilting uplift, is 50 feet lower.

The Ballston Lake channel is today horizontal, 300 feet at each end. The south (upper) portion of the ancient channel has been cut away by the intrenching of Alplaus creek, graded to the Mohawk. It is apparent that the Iromohawk in the northward flow had sufficient fall to have kept that path unless some outside force intervened. The differential north-uplift supplied the interference. The northward flow was weakened and discouraged, and was diverted from the Ballston Lake channel into the present narrow channel eastward toward Cohoes. Stoller referred the diversion of flow to the more rapid downcutting of the present channel at Rexford Flats and Aqueduct. But the constriction of the channel at Aqueduct and at Cohoes indicates that this course was mostly cut by the present diminished stream and not by any long-time flow of the great predecessor of the St Lawrence.

As to relative time and altitude of the eastward diversion of flow we have some data. The Maltaville distributary made channels in

rock about the west side of the Round lake ice block down to what is now 200 feet altitude. As the total submergence at Round lake was over 375 feet, there had been an uplift of at least 175 feet before the Iromohawk flow entirely ceased. Apparently the subsequent uplift, 200 feet or somewhat less, has not produced much tilting, as the Ballston Lake channel is even now horizontal. All of which is in harmony with the view that the earliest uplift was by a wave of moderate dimensions, 100 miles or less in breadth (18, page 252).

ROUND LAKE; AN ICE-BLOCK KETTLE

Three lakes lie in this area which have interesting forms and peculiar relationship to other features. Professor Woodworth regarded the Saratoga and Round Lake basins as "unfilled depressions marking the site of an old valley west of the present Hudson gorge" (4, page 76). Mr J. H. Cook has written on this hypothetical valley (5). The question is pertinent. Why are the depressions unfilled? This is specially pertinent regarding Round lake, as we see that it lies precisely in the path of one of the powerful distributary channels of a great river. Such basins could not persist in the line of heavy drainage loaded with detritus. The sand plains about these lakes are proof of the volume of river-borne detritus. Professor Stoller thought that the Round Lake basin had been filled and was later reexcavated by the stream. He says: "Deposits of clay and afterward of sand, made widely in Lake Albany, filled in the basin and for the time obliterated it. When Lake Albany began to subside powerful currents of water entering from the Ballston channel cut into the deposits. The erosion of the deposits. . . . resulted in the present topography." (7, page 22) His figure (no. 3, page 23) gives four diagrams illustrating this conception of the basin's origin. But it seems impossible for a stream to excavate its own deposits and produce a circular basin of the size and relations shown in the topographic map. It is evident that the basin did not exist when the Maltaville river was flowing.

The simple and entirely sufficient explanation of Round lake is that it occupies an ice-block kettle. The recognition of drift-buried ice blocks as an agency in the production of basins in moraines and deltas has been the greatest help in the interpretation of these peculiar and formerly inexplicable phenomena. And the explanation fits the present case perfectly.

At full height the sea-level waters lay over the Round lake district

at 380 feet altitude and swept the plain at Malta four corners at 390 feet. During the time of the Iromohawk flow the detritus carried by the Maltaville tributary seems to have been carried around the ice block and eastward to form the delta plains west of Mechanicville. If the basin had existed during the episode of the river flow it would surely have been filled, as Stoller recognizes, but in such case it would have been channeled as the standing waters fell, and today we should find there a detrital plain with a channel traversing it, similar to the Willow Glen gorge toward Mechanicville.

The topography of the basin indicates that the ice block originally occupied the space north and east of Maltaville and south as far as Usher. The abrupt limits of the higher sand plains indicate a barrier to their extension. The block of ice probably occupied all the rotund area within the 300 feet contour, with dimensions about 3 miles north and south and over 2 miles east and west. This is suggested on the map by the area shaded in green.

Distinct stream channels appear west of Round Lake village at 300 feet altitude, while lower cutting, in rock, shows in the eastern edge of the village and close to the lake down to 200 feet. This proves that the district had lifted out of the standing water to that level. The total uplifting has been over 375 feet; hence 175 feet of rise had occurred while the persistent but diminished ice block held the flow to its southward course past what is now the west side of the lake. The topography suggests that at this time the ice mass had shrunk to about the limits of the 200 feet contour.

A series of terraces north and east of the lake shows the effects of the lowering waters lying against the waning ice, while the broad plain south of the lake shows the eroding and leveling work of the latest river flow. The ravine below East Line and the deeper channel of the Anthony kill toward Mechanicville have been deepened by the present creek.

Some explanation of the cause for the long persistence of drift-buried ice blocks may be found in another writing (17, pages 232-33).

ORIGIN OF SARATOGA LAKE

The basin of Saratoga lake, like that of Round lake, appears to be an ice-block depression. The abrupt fronts of the delta sand plains west and south of the lake suggest that they were banked against an obstruction. It would seem that the heavy flow of the Drummond tributary would in free course have spread the detritus into the

lake area, instead of leaving the plains with steep fronts more than 100 feet high. A significant fact is that the low plains bordering the lake on the west and south have the same height as those about Round lake, namely, 200 to 220 feet.

Probably the lake has been elevated and enlarged by the land tilting and the lifting of the northward outlet through Fish creek.

Professor Woodworth recognized the evidences of ice occupation of the Round and Saratoga Lake basins, but attributed the fact to the slower melting of the western side of the Hudson ice lobe (4, pages 135-36). He says: "The ice remained longer over the depressions occupied by Saratoga and Round lakes than it did in the Hudson valley, immediately east of this district. The large streams coming into the Hudson valley from the open ground on the east probably favored the melting of the glacier more rapidly on the side where their waters coursed along the ice margin." But the ice margins here were not swept by rivers but laved by deep, open waters. The lake basins were occupied by ice blocks detached from the glacier front, and more or less protected by glacial and delta drift. And the blocks of ice persisted while the ice front receded unknown miles to the north.

ORIGIN OF BALLSTON LAKE

This lake lies in the rock channel of the great Iromohawk river. If it were quite shallow it might be thought due to the differential northward uplift, along with the vegetal accumulation as a swamp at the outlet. But in a letter to the writer Professor Stoller says: "The depth is 109 feet at a point about 400 feet from the southern end of the lake. Farther to the north, about half a mile from the southern end, the depth measured 55 feet."

As this lake lies along a line of faulting (see Cushing, 8, page 105) it may possibly be attributed to postglacial dislocation and be called a "graben." The earlier faulting possibly determined the course of the river flow. The subject deserves further study.

ABSENCE OF MARINE FOSSILS

Because marine fossils have not been found in the water-laid deposits of the Hudson valley, some geologists have regarded the ancient waters as glacial, not as confluent with the sea. But marine life should not have been expected, for some consideration of the physical conditions shows that salt-water organisms could not enter

the upper Hudson valley. In this connection it is well to note that the Hudson is today tidal water to Albany and Troy, but marine life does not exist far above New York City.

In the Hudson valley the land drainage always passed south, as at present. During all the long time that the Labradorian ice sheet lay on New York the enormous flood of the glacial melting was added to the southward flow. This fact and its biologic effect does not appear to have been sufficiently recognized. From a time much earlier than the initiation of Lake Iroquois all the waters now represented by the St Lawrence, and in addition the wastage of the Labradorian ice cap, passed south through the Hudson valley, with its constriction at the West Point highlands. And this flow lasted until the waning glacier front receded from the high ground in Maine and New Brunswick and permitted the St Lawrence gulf to unite with the Champlain sea. Then the Hudson-Champlain estuary became the Hudson-Champlain strait, connecting the Gulf of St Lawrence with the New York bay. Up to this time the flood of fresh water was too great to allow marine life to pass up the Hudson.

When broad connection was made between the Champlain interior sea and the salt water of St Lawrence gulf a free circulation and interchange was established and marine life entered the Champlain, Ottawa and St Lawrence valleys. But this event had been long delayed and in the meantime something else had happened. The rising of the land, as it was relieved of the weight of the ice sheet, had lifted the Hudson and Champlain areas so that the sea-level waters then stood far below the initial shore line.

In these facts of Pleistocene history we find a perfect explanation of the absence of marine fossils from the earlier and higher deposits of the sea-level waters, while they are abundant in the lower deposits of the northern valleys.

After the land on the Canadian boundary had lifted 215 feet there seems to have been a much slower uplifting, or relative pause, which produced the strong, close-set beaches about the north side of Covey hill, with summit altitude of 525 feet. It is possible that during this episode the salt-water life entered the Champlain valley.

The question may yet be asked, Why did not the same marine fauna found in the lower sand plains of the Champlain valley pass south into the Hudson valley? There is satisfactory reply. The land uplift was a wave movement progressive from south to north. Uplifting had been in progress for a very long time in the Hudson area before the Champlain area was much affected. By the time

that marine organisms entered the Champlain valley the divide, near Fort Ann had possibly been lifted out of the sea-level waters. If Covey hill had been raised 215 feet then perhaps Fort Ann might have been raised the 300 feet necessary to make it dry land and break the connection of the two valleys. However, even if a narrow sea-level strait yet existed between Whitehall and Fort Edward, and salt-water organisms were swept by unusual storms southward into the Hudson section, they undoubtedly found a freshened condition of the Hudson water that was unsuited to their propagation. And after the Fort Ann strait was abolished the southward sweep of river waters certainly forever prohibited sea life from passing far up the Hudson estuary.

The altitude relation of the Upper Hudson valley to the Champlain waters is an interesting problem. The topography of the river channel in the district shown by the map does not indicate the flow of a stream much if any larger than the present Hudson. But if the detrital filling of the valley had been lifted above sea level while the Champlain glacial waters were yet forced southward a river much larger than the St Lawrence would have swept the valley. It would, therefore, appear that the waning Labradorian glacier had given the Champlain waters an eastward connection to the sea before the Fort Edward-Cohoes section of the valley was exposed to river work.

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